SHEEP PRODUCTION

S.K. KAUSHISH

भाकृअनुप
ICAR

Indian Council of Agricultural Research
New Delhi

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Preface

The current population of sheep in India is about 61.8 million, whereas developed countries of the world have about 45% of sheep and the developing countries on the other hand have about 55% of sheep population. Presently, the sheep in India are providing 230 million kg mutton, 53.7 m kg wool and 52.4 m kg skins annually. Sheep plays a vital role in the livelihood security of over 9m population of small and marginal farmers and landless labourers. Since sheep are reared under ecologically poor zone, they are blamed for causing vegetative destruction, soil erosion and desertification.

The gravity of situation can be gauged from the fact that India with only 2.30% of the land area of the world is maintaining nearly 16.65% of the world human population and about 20.01% of the livestock population. Studies conducted have revealed that a marked improvement can be achieved in the overall productivity through food and fodder resource development and their effective utilization.

The targeted growth rate of 8% of Indian economy during eleventh five-year plan is possible only if we achieve growth rate of 4% in agriculture. The growth rate of 4% in agriculture is possible only if a growth rate of at least 7.5% is achieved in livestock sector.

The subject of sheep production and management has been introduced in many agricultural universities at graduate and postgraduate levels. Many books have been written by foreign authors and we have been following them. As the climate of this region is different from that of those countries, these publications are far away from realties under our conditions.

The aim of this book is to present consolidated latest information on different aspects of sheep production accrued through research and development programmes undertaken during the last five decades. The information has been compiled/collected from the reports/published works of various authors.

Very few books have been written on sheep management under our conditions. As these are not according to the syllabi being followed in agricultural universities. The present work is not the sole effort of the author but is a compilation of research findings of a large number of academicians, research workers including rural people. The author has brought out the present book keeping in view the requirements of

undergraduate and postgraduate students of sheep production, the teachers, scientists, farm managers and planning officers, development agencies and administrators. The aim has been to present a comprehensive volume of information.

I am indebted to many of my colleagues, who have made the writing of this book possible in particular to Dr V.K. Taneja, the then DDG (Animal Sciences), Dr S.A. Karim, presently working as Director of CSWRI, Avikanagar. I am also thankful to Director CSWRI, Avikanagar, for allowing me to use some of the photographs. I am equally indebted to all the faculty members of the Division of Animal Science and Forage Production. I am highly thankful to Shri Suresh Chander Roj, Shri Om Prakash Jayal and Shri Kailash Chohan who have shared the burden of some of the development work reported.

In the end, I would like to express my feelings of gratefulness to my wife, my son and his wife and my daughter and her husband for their continuous moral support.

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1.

General View

Sheep were domesticated long before the dawn of recorded history. Wool fibers have been found in the remains of primitive villages in Switzerland that date back to an estimated 20,000 years. Sheep and goat were first domesticated by man between 7500 and 6500 BC for meat and milk (Harlan, 1976). Mention is made in the Bible of sheep flocks and lambs.

At that time humans would follow feral flocks of sheep from their winter valley pastures as they migrated to the cooler, High Mountain pastures. Early humans, in their search for food, clearly recognized a valuable species with the capability of providing both meat and skins (Zeumer, 1963).

The Soay, a primitive type of sheep still found in Britain, may be typical of the original domesticated types, with a hairy outer coat and a dense undercoat of short fine wool.

Very little information is available about the original selection and domestication of sheep; they are thought to have descended from wild type like the Moufflon sheep. Selection practices not only removed most of the wild instincts, leaving the species completely dependent on man for management and protection, but the tail also lengthened. As weaning began to develop as an important advancement, more definite type and breeds of sheep began to emerge. A breed was developed in Spain for fine wool. The English also developed many breeds that would adapt to their varying climate. Spain and England developed as two super powers in wool production between 1000 and 1500 AD Most of the breeds we come across in U.S. are from these two stocks.

Columbus introduced domestic sheep in West Indies during his second voyage in 1493. With the invasion of Spain by Napoleon, Merino spread to other parts of the world. Some along with many English breeds found their way to the United States, where their number increased.

Now a days, the sheep is remarkable in the diversity of its varieties, breeds and crosses. The historical development and inter-relationships

of the significant types have been studied comprehensively by Ryder and briefly outlined elsewhere (Cunningham and Stamp, 1987).

Sheep have become widely distributed with types adapted to a considerable range of climatic conditions varying from semi-arid to cold, moderate rainfall conditions (500-1500 mm annual rainfall). Sheep of different types have adapted to a wide range of temperatures, from sub-zero in winter in several countries to 25°C or so on the fringes of continental deserts.

The global distribution of sheep has developed not only because of their physiological capacity to adapt, but also as a consequence of historical and socio-economic factors. A range of types has been bred to meet specific commercial purposes. The four main products - meat, wool, manure and milk - vary in importance, from the use of multi-purpose types encompassing all products to those providing a single product, the former being more important in peasant economies.

Wool as a primary product is associated with systems in the semi-arid areas of the world, notably in the Southern hemisphere, where Australia, South Africa and South America produce Merino-type wool.

In areas with a temperate climate, meat production predominates with New Zealand, Great Britain, Ireland and Australia being important producers.

Milk, which is converted mainly into cheese or to yogurt, is important in many parts of the world, but is specially so in the Mediterranean area, parts of Asia and Africa. Roquefort cheese is manufactured mainly from ewe's milk in the South of France and has a worldwide market. In recent times, specialist dairy flocks have sprung up throughout the UK, producing cheeses, which meet a ready market.

Classification

All the sheep have several characteristics in common. As a member of animal kingdom, they belong to the Phylum *Chordata* (back bone), class *Mammalia* (suckle their young ones), order *Artiodactyla* (hooved, even footed), family *Bauidae* (ruminants), genus *Ovis* (domesticated and wild sheep) and species *Ovis aries (*Within this species many different breeds exist). All the pure breeds and crossbreds have their place. Classification of different species is given in Table 1.1 (Kaushish 2009).

Sheep are important in the utilization of vast areas of grazing land, be it mountainous, hill or range, much of which is unsuitable for other agricultural purposes, but sheep are also integrated into systems in the more productive cropping areas to utilize crop residues, maintain soil fertility and to integrate grassland into crop rotations.

Classification of the many sheep systems is difficult because of the remarkable degree of diversity, yet there are many overlapping features. At one extreme are the nomadic and transhumance systems, mainly of a subsistence nature, which have survived for thousands of years with virtually no change. The former involves the movement of families or larger groups and their flocks, usually sheep and goats, from the lowland to summer pastures in the mountains. In contrast, in transhumance systems, the human population may be essentially settled cultivators, where shepherds move the livestock to different altitudes in the appropriate seasons. Sparse vegetation, disease challenge and climatic stress have led to an element of hardiness in nomadic breeds with physiological traits, e.g. resistance to parasites, which distinguishes them from exotic types. Breeds tend to have either hairy or coarse wool coats, while production of milk and meat is modest, but all of these, along with skins, are much valued by their owners (Bahara, 2003).

In the developing countries in Asia and the Middle East and to a diminishing degree in Europe, sheep may be owned by individual villagers, usually in small numbers, but are kept in communal flocks. They will use crop residues and, in the growing season, a shepherd may take the flock to a common grazing, which is frequently overgrazed, with the consequence that production levels are poor (Kaushish, 1980).

In the mountains, hills and rangelands of the world, extensive systems have been developed and these vary to a remarkable extent. Those that may be described as very extensive are characterized by low stocking density (2-10 ha/sheep is not unusual), minimum husbandry (6-10,000 sheep or more per man) and low productivity. In the areas of low rainfall (120-400 mm/annum), specialized wool production predominates and is based on Merino or Merino-type sheep. Nonetheless, supplements or nutrient licks for specific deficiencies may be used and limited areas may be fertilized and over sown, as in the high country in New Zealand. Systems of this type are to be found in Australia, South Africa, South America and Asia.

The mountainous and especially the hill areas, with high rainfall (1,000 mm or more), cold winters and a short growing season coupled with poor soil fertility, support extensive systems. The land may be fenced; grazing management imposed and overall there is a higher labour input.

There is frequently a complementarity between hill and lowland areas, as lambs for finishing and breeding animals are transferred to the more favorable conditions. In the USA and Russia, large feedlots using maize or its by-products are common, while other countries use suitable food crops grazed *in situ*.

Table 1.1 Classification

Class	Mammalia
Subclass III	Eutheria (females possessing placenta)
Order IV	Ungulata (hoofed mammals)

Suborder 1. Artiodactyles (even toed animals)	Suborder 2. Perissodactyles (uneven toed animals)
A. Suina	Family : Equidae
Family C: Suidae	(horses, donkeys and zebras)
(true pigs)	Genus: *Equs*
Genus: *Sus*	1. *Equs caballus* (horse)
Sus domesticus (domestic pig)	2. *Equs asinus* (donkey)
B. TYLOPODA	(*Note*: Mule is a cross between
Family: Camilidae	male ass and female horse.
Genus: *CAMELUS* Linn	Jennet is a cross between female
1.Camelus dromedarius Linn (Arabian camel)	ass and male horse. Both are sterile)
2. *Camelus bactrianus* Linn (two-humped Bactrian camel)	
C. Pecora (true ruminants)	
Family d : Bovidee (hollow horned)	
Genus: *Bos*	
1. Taurine group:	
Bos taurus (humpless cattle)	
Bos indicus (humped or zebu cattle)	
2. Bubaline group:	
Bos (Bubalus) bubalis (Indian water buffalo)	
Genus: *Ovis*	
Ovis aries (domestic sheep)	
Genus: *Capra*	
Capra hircus (domestic goat)	

Because of nutritional and physiological stresses, disease and predation, output may be low. Amelioration of soils, modification of indigenous pastures by seeding, or its replacement in small areas and removal of nutrient deficiencies, including mineral inadequacies, can lead to significantly increased output. Large flocks are common, 500 or so to several thousand and are to be found in Northern Europe, New Zealand and North America.

In areas, where, pasture production is favourable, usually in the temperate areas, higher concentrations of stock under a tight management regime become feasible. Such conditions are to be found

in Great Britain, Ireland, New Zealand, and parts of France, Austria, Spain and the Pacific northwest of the USA. Feed supply and demand can be closely equated by changes to the grass growth profile and by the use of conserved forage, other crops or purchased feeds (Kaushish, 2009).

To sustain the high-cost structure, output levels have to be high and technological competence is vital. The main product is lamb for slaughter at a young age or stores for finishing at under a year old. Sheep are incorporated into arable systems, such as in Great Britain and areas of Australia, where pasture may be an integral component of a rotational system and crop by-products contribute to the food supplies.

Sheep are now being used for wool, hairs, pelt, apparel, blankets, carpets, etc. Endocrine glands of slaughtered sheep are used for making some medicines, fat for making candles and intestines for sausages. Sheep and goat husbandry is the main occupation in arid and semi arid areas. Availability of water is poor in these areas. Watering sheep once in two days does not affect production. They can climb steep mountains easily.

Variation is found in size, wool production, reproduction and adaptation. The sheep population of different countries is presented in Table 1.2. These figures are according to FAO (2004). Sheep population per hectare in New Zealand, South Africa, Australia and England is highest in the world.

World Sheep Population

There are 1030 million sheep in the world, out of which, 14 and 13 per cent are found in Australia and former USSR, respectively. Twenty six per cent sheep (268 million) of the world are found in Asia. They are found in larger numbers in China, Turkey, India and Iran. Seventy per cent of the total sheep population of Asia is found in these countries. Their number increased by 13 per cent between 1955 and 1975 (Table 1.2). During 1955 and 1975 the sheep number decreased by 44 per cent in North and Central America, whereas, it increased by 38 per cent in former USSR during the same period.

Sheep population increased by 3 per cent in Europe during this period. Largest number of sheep in Europe is found in Bulgaria, France, Romania and Spain. Of the total 113 million sheep found in South America, 23 and 32 per cent alone are found in Brazil and Argentina, respectively. Their number decreased by 4 per cent.

There were 240 million sheep in Africa according to 1999 census. The sheep population registered an increase of 35 per cent between

Table 1.2 World sheep population (,000)

Country	Year		
	1978[$]	1989-91[+]	1999[+]
World		11,93,083	10,68,669
Africa		2,06,736	240,342
Algeria	9,500	17,301	18,200
Angola		240	336
Benin		869	634
Botswana	840	317	250
Burkina Faso		5,048	6,350
Burundi		352	165
Cameroon	2,100	3,407	3,880
Cape Verde		6	9
Central African Republic		134	201
Chad	2,400	1,926	2,432
Comoros		13	20
Congo Dem Rep		930	930
Congo Rep		104	115
Cote Devoir		1,137	1,370
Djibouti		433	463
Egypt	1,900	3,310	4,400
EQ Guinea		35	36
Eritrea		23,320	
Ethiopia PDR	2,310		1,570
Gabon		161	195
Gambia		127	190
Ghana	1,500	2,199	2,516
Guinea		429	687
Guinea-Bissau		239	280
Kenya	3,900	6,447	5,800
Lesotho		1,450	720
Liberia	200	222	210
Libya	3,000	5,100	6,400
Madagascar		737	790
Mali	4,400	6,072	5,975
Mauritania	4,400	5,067	6,200
Mauritius		7	7
Malawi		151	110
Morocco	14,300	13,528	16,576
Mozambique		120	124
Namibia	5,000	3,289	2,100
Niger	2,500	3,100	4,312
Nigeria	8,100	12,477	20,500

Table contd.

Table Contd.

Country	Year		
	1978[$]	1989-91[+]	1999[+]
Reunion		2	2
Rwanda		392	290
Helena		1	1
Sao Tome PRNS		2	3
Senegal		3,464	4,300
Sierra Leone		271	350
Somalia		12,783	13,500
South Africa	31,200	32,060	28,680
Sudan	18,200	21,304	42,500
Swaziland		24	26
Tanzania	3,000	3,551	4,150
Togo		1,164	740
Tunisia	3,600	5,935	6,600
Uganda	1,100	1,350	1,970
Zambia		59	120
Zimbabwe		544	52
N.C. America		18,899	15,151
Antigua Barb		13	12
Aruba		13	12
Bahamas		7	6
Belize		4	3
BR Virgin is		6	6
Canada		595	656
Costa Rica		3	3
Cuba		385	310
Dominica		7	8
Dominican Rep		115	105
El Salvador		5	5
Greenland		21	22
Grenada		12	13
Guadeloupe		4	4
Guatemala		120	138
Haiti		120	138
Honduras		10	14
Jamaica		2	2
Martinique		46	42
Mexico	7,900	5,862	5,900
Montserrat		4	5
Nethantilles		6	7
Nicaragua		4	4

Table contd.

Table Contd.

Country	Year		
	1978[$]	1989-91[+]	1999[+]
Puerto Rico		7	8
St. Kits Nev		14	8
St Lucia		15	13
St Vincent		13	13
Trinidad &Tobago		14	14
US Virgin Is		3	3
USA	14,000	11,128	7,238
South America		104,243	80,594
Argentina	34,000	28,139	14,000
Bolivia	7,800	7,573	8,575
Brazil	17,300	20,061	18,300
Chile	5,700	4,803	4,116
Columbia	2,100	2,547	2,196
Ecuador	2,200	1,417	2,180
Falk Land Is		738	708
Fr Guiana		4	3
Guiana		129	130
Paraguay		422	395
Peru	145	12,484	13,700
Suriname		9	11
Uruguay	17,800	25,359	15,500
Venezuela	100	558	781
Asia (FMR)		348,641	378,682
Asia			412,608
Afghanistan		14,173	14,300
Armenia			575
Azerbaijan		4,648	5,132
Bahrain		20	17
Bangladesh	1,200	871	1,110
Bhutan		49	59
China	76,000	112,299	127,162
Cyprus		300	250
Gaza Strip		24	24
Georgia			550
Hungary	2,300		
India	40,300	48,708	57,600
Indonesia	3,300	6,008	8,152
Iran	35,000	44,752	53,900
Iraq	11,400	8,127	6,000
Israel		383	340

Table contd.

Table Contd.

Country	Year		
	1978[$]	1989-91[+]	1999[+]
Japan		30	16
Jordan		1,660	
Kazakhstan			9,000
Korea D P Rep		496	185
Korea Rep		3	1
Kuwait		197	445
Kyrgystan			3,400
Lebanon		221	355
Malaysia		212	168
Mongolia		14,266	14,692
Myanmar		275	379
Nepal		903	855
Oman		204	160
Pakistan		25,307	31,300
Philippines		30	39
Qatar		126	207
Saudi Arabia		6,370	8,300
Sri Lanka		25	12
Tajikistan			1,620
Thailand		161	41
Turkey	41,500	43,195	30,238
Turkmenistan			5,650
United Arab Emirate		255	440
Uzbekistan			8,000
Yemen	4,400	3,682	4,595
Europe (FMR)		158,246	138,273
Europe			154,256
Albania		1,645	1,941
Austria		284	384
Belarus			122
Bel-Lux		174	155
Bosnia Herzog			285
Bulgaria	9,700	8,226	2,774
Croatia			489
Czechoslovak		1,043	
Czech Rep			94
Denmark		164	156
Estonia			31
Faeroe Is		67	68
Finland		59	128

Table contd.

Table Contd.

Country	Year		
	1978[$]	1989-91[+]	1999[+]
England	28,000	43,493	44,656
France	10,900	11,196	10,240
Germany		3,824	2,298
Greece	8,100	8,624	9,290
Hungary		2050	909
Iceland		540	477
Ireland	3,500	5,523	5,624
Italy	9,400	11,088	10,770
Latvia			27
Liechtenstein		3	3
Lithuania		28	16
Macedonia			1,550
Malta		9	16
Moldova Rep			940
Netherlands		1,663	1,465
Norway		2,202	2,399
Poland	3,500	3,934	392
Portugal	3,700	5,531	5,800
Russian Fed			13,650
Slovakia			326
Slovenia			72
Spain	15,600	23,280	23,751
Sweden		408	420
Switzerland		392	490
Ukraine			1,198
Yugoslavia	7,500		
Oceania		222,912	165,718
Australia		165,046	119,600
Fiji Islands			7
New Caledonia		3	4
New Zealand	5,900	57,861	46,100
Papua New Guinea		4	6

Source: $ FAO, 1978 Production Year Book; and +FAO, 2004. Production Year Book; Vol **53:** 207-9

1955 and 1975. Fifty per cent of the total sheep population of this Continent is found in South Africa, Ethiopia, Morocco and Sudan alone. Australia is the biggest wool producing and exporting country of the world. About half of the world merino wool is produced here. Australia produces about one third of the world wool (Table 1.3).

Table 1.3 Mutton, milk and wool production in various countries of different continents

Continents/ Countries	(%) Of total milk production	Washed wool (kg per sheep)	Meat production from sheep and goats (1,000 tonnes)
Asia			
Afghanistan	41.50	0.75	5.93
China	21.50	0.71	5.11
India	-	0.52	0.67
Iran	30.20	0.36	7.49
Iraq	45.50	0.48	0.85
Mongolia	19.90	0.94	64.84
Nepal	-	0.99	1.44
Pakistan	-	0.71	1.18
Syria	41.9	1.15	6.96
Turkey	21.5	0.71	5.11
Yemen	20.2	-	8.89
Africa			
Algeria	21.7	0.75	2.86
Ethiopia	0.8	0.01	3.67
Lesotho	-	0.67	3.69
Mali	16.3	0.04	6.18
Morocco	29.2	0.41	5.14
Nigeria	-	-	1.84
South Africa	-	1.89	8.05
Sudan	7.0	0.22	6.24
Tunisia	22.2	0.71	2.16
Australia			
Australia	-	2.79	58.86
New Zealand	-	3.81	190.44
South America			
Argentina	-	2.00	7.60
Bolivia	38.1	0.53	3.88
Brazil	-	0.82	0.59
Chile	-	1.67	2.15
Uruguay	-	2.25	11.84
Europe			
Albania	25.40	1.13	12.88
Bulgaria	18.82	1.52	9.31
England	-	1.19	3.90
France	2.90	0.84	2.41
G.D.R.	-	2.10	0.63
Greece	33.40	0.58	10.30
Hungary	2.90	1.89	0.48
Italy	4.40	0.68	1.00
Ireland	-	2.33	16.38

Table contd.

Table Concluded

Continents/ Countries	(%) Of total milk production	Washed wool (kg per sheep)	Meat production from sheep and goats (1,000 tonnes)
Poland	-	1.69	0.75
Portugal	12.50	0.60	1.84
Romania	9.54	1.28	4.00
Spain	3.93	0.72	3.97
USSR	0.10	1.80	3.95
Yugoslavia	5.20	0.82	2.41

Indian Sheep Population

Sheep plays a pivotal role in the rural agrarian economy of arid and semi arid zones in India. Millions of small and marginal farmers and landless labourers are solely dependent on sheep production for earning their livelihood. A variety of products are produced from the sheep farming industry ranging from wool/woollen products, leather/leather products, meat/meat products, manure and milk to a limited extent. According to estimates of Central Statistical Organization, the value of the output from Livestock and Fisheries sector together at current prices was about ₹ 2,25,675 crores at current prices during 2005-06 (₹ 1,85,166 crores Livestock sector and ₹ 40,675 crores for Fisheries), which is 30% of value of output of ₹ 7,20,340 crores from total of agriculture, Animal Husbandry and Fisheries sectors. The contribution of these sectors to total GDP during 2005-6 was 5.6%. The egg production and wool production in the country has reached 46.6 billion numbers and 44.99 million kg, respectively in 2005-6 (GOI 2008). Export of sheep and sheep products fetch a considerable amount of foreign exchange. In 2005-6 only meat and edible offals exports were at the level of 13% (ICAR 2006).

The sheep population in India is estimated to be about 61.8 million (ICAR 2006) (Table 1.4), ranking third in the world and about 4.57% of the world population. About 169 m kg of mutton, 44.99 m kg of wool (GOI 2008) and 40 m kg of skins is produced annually in the country. The national sheep wealth is about ₹ 2,400 crores producing an annual income of about ₹ 8,000 million in the form of wool, meat, skin, milk and manure. According to a survey conducted by Central Sheep and Wool Research Institute, in the district of Tonk, the average gross income per sheep was ₹ 456; 8.65% from wool, 81.36% from live animals, 3.26% from milk and 8.5% from manure (ICAR 2005). However, sheep have a low productivity as compared to its recorded potential within the country and abroad (Suresh *et al.* 2008). Low

Table 1.4 Sheep population in different states of India (in '000)

State	1972	1977	1982	1987	1992	2003	Change during last decade
Andhra Pradesh	8,343	7,064	7,519	6,872	7,787	21,376	–
Arunachal Pradesh						17	–
Assam	5						
Bihar	933	59	46	67	150	75	–50.0
Chhatisgarh		1,121	1,322	1,520	1,690	431	–68.5
Gujarat	1,732					121	–
Haryana	459	1,592	2,357	1,557	2,027	2,021	–0.003
Himachal Pradesh	1,000	541	756	890	1,044	633	–39.4
Jammu & Kashmir	1,070	1,055	1,090	1,112	1,079	1,099	+1.9
Jharkhand		210	1,909	2,493	2,947	3,745	+27.0
Karnataka	4,662					679	–
Kerala	10	4,536	4,792	4,727	5,432	7,256	+33.6
Madhya Pradesh	1,009	3	7	30	29	5	–86.0
Maharastra	2,128	968	959	835	836	546	–34.7
Manipur	2	2,636	2,691	2,872	3,070	3,122	–1.5
Meghalaya	18	2	14		14	6	–57.0
Mizoram		20	26	75	23		
Nagaland							
Orissa							
Punjab				1,369			
Rajasthan							
Sikkim							
Tamil Nadu							
Tripura							
Uttar							

lines. The state wise sheep population trend is given in Table 1.4. Native ewes and rams on an average weigh 20 to 30 and 30 to 40 kg, respectively. They produce medium to low quality wool varying from 0.25 to 1.75 kg. Some of the exotic breeds weigh 90 to 120 kg and produce much more wool.

Wool Production

Wool production has increased from 27.5 m kg in 1951 to 52.6 m kg in 2003-04 (ICAR 2005). The wool production and quality in different regions are presented in Table 1.5. The north- western region has ~42% of total sheep contributes about 65% of wool produced. The average of wool production per sheep is only 0.9 kg against the world types, it being ~4. About 50 kg of wools (both apparel and carpet it may not be possible to meet the requirement of the industry. While there is every possibility of meeting apparel wool in required quantity, suitable and thrust in expansive development requirement of carpet wool with items, etc. Thereby hand-knotted programmes. India can make a to be given due emphasis carpets, druggets, hosiery 2007 Livestock Census quantity and quality of carpet wool has Sheep population are 11.28 m in Rajasthan as per the wool production figures (2009).

Asia contributes 4.57% of world population for Asia's share in world wool production. The production of mutton, wool in Table 1.6 along

Table 1.6 Sheep production status in India and the world

Attributes	India	Asia	World
Sheep population (million)	50.79	344.05	1,111.00
No.of sheep slaughtered /annum (m)	15.83	155.02	466.73
Mutton production (m.kg.)	190	2,217	6,914
Wool (greasy) m. kg	45.6*	525	2,696
Sheep skins fresh	45.5	427.0	1,324.0

Source: FAO (1993) * Ministry of Agriculture. Govt. of India

Sheep Development Activities

Sheep and goats are two important livestock species, which make substantial contribution to the rural economy of the country. These two livestock species together are valued at approximately ₹ 80,000 million. The marginal farmers and landless labourers who are the poorest in the rural society mostly rear the sheep and goats. About 5 million families are estimated to be engaged in various activities relating to rearing of sheep and goats and utilizing their products. A majority of the farmers rearing sheep and goats maintain themselves at subsistence levels.

Due to lack of focused developmental efforts for improvement of these two species, they are at present having very low productivity compared to the recorded potential of the species. The major factors contributing to the low productivity of the small ruminants include poor exploitation of genetic potential of indigenous animals, inadequate resources of feed and fodder, insufficient health cover and inadequate marketing and credit support, etc.

Crossbreeding in sheep for improving wool production started in 19th century by the East India Company, which imported exotic breeds for crossbreeding with the indigenous sheep breeds. Crossbreeding experiments using exotic fine wool breeds, particularly Cape Merino was started and crossbred sheep were raised around Poona, which produced more wool of superior quality. In the first decade of 20th century, crossbreeding of indigenous sheep with Romeny Marsh was taken up both in plains and hilly areas. Some crossbreeding trials were undertaken in Punjab, Bengal, Mysore and Madras using South Down and Cape Merino. During sixties importing Rambouillet sheep from Texas (USA) to undertake cross breeding programme started the sheep improvement programme. Subsequently during seventies Soviet Merino sheep were imported from Stavropol, for crossbreeding the indigenous medium wool producing sheep for fine wool production. Dorset and Suffolk sheep were imported for crossbreeding the indigenous sheep to evolve new mutton type breeds. A small flock of exotic breeds of Romeny Marsh and South Down and 350 Rambouillet sheep were imported in

1964. Subsequently, Russian Merino, Corriedale, Dorset and Suffolk sheep were added to the exotic germ plasma resource. Indigenous breeds of sheep viz. Chokla, Coimbatore, Gaddi, Malpura, Nali, Nilgiri and Sonadi were used for crossbreeding to improve wool production, wool quality and mutton production.

During the Third Five-Year Plan, large number of sheep and wool extension centers were established besides strengthening the existing sheep breeding farms and a large scale sheep shearing, wool grading and marketing programme was initiated in Rajasthan. This was subsequently extended to a number of other states in North and Northwestern region. In 1962, realising the importance of sheep in the agrarian economy, the Central Government established Central Sheep and Wool Research Institute (CSWRI), at Malpura (Rajasthan) for undertaking the fundamental and applied research in sheep production and wool utilization and to provide post-graduate training in sheep and wool sciences.

During the Fourth Five Year Plan, 84 sheep breeding farms, 602 sheep and wool extension centers and 52 supplementary sheep breeding centers were in operation in the country. The Government of India constituted the ad-hoc Sheep Breeding Policy Committee in 1970, which suggested that in order to meet the shortage of stud rams, 20,000 exotic sheep of fine wool breeds for producing breeding rams should be imported. For achieving this objective, an Indo-Australian (now Central) Sheep Breeding Farm was set up at Hisar with a foundation stock consisting of 3,000 ewes and 300 rams of Corriedale breed for production and distribution of Corriedale stud rams to different states for cross breeding to improve wool and mutton production. Corriedale did not perform well especially with respect to reproduction and survival and was later replaced by Rambouillet. Two large sheep breeding farms were also set up in the private sector, one in Maharashtra and the other in Gujarat for producing purebred and crossbred rams. Seven more such Central Sheep Breeding Farms were established in Jammu and Kashmir, Uttar Pradesh, Madhya Pradesh, Bihar, Andhra Pradesh and Karnataka to produce exotic purebred or crossbred rams.

During the Fifth Five Year Plan, a large number of breeding farms were established in the central and state sectors to produce genetically superior breeding stocks, to increase their sheep population and strengthen feed availability. It was also planned to reorganize and strengthen the existing sheep breeding farms in the states as well as expand and reorganize sheep and wool extension centers and to set up scientific sheep shearing and wool grading programmes. Intensive sheep development programmes were also initiated which included genetic up

gradation through supply of superior males, providing health cover, improving pastures on communal grazing lands and machine shearing, grading and marketing of wool.

A number of sheep development programmes were undertaken under other rural development programmes, such as Drought Prone Area Programme (DPAP), small farmer (SF), marginal farmers (MF) and agricultural labour (AL) schemes. Wool Boards were set up to grade and market wool in important wool producing states.

As a result of crossbreeding, improved strains were evolved, e.g. Hissardale by crossing Bikaneri ewes with Merino rams at Hisar and Kashmir Merino by crossing indigenous breeds like Gaddi, Bhakarwal, Rampur Bushair, Poonchhi, Karnah and Gurez with Merino. Under the All-India Co-ordinated Research Programme (AICRP) on sheep breeding initiated by the ICAR in 1971 and institutional research programmes undertaken by CSWRI, Avikanagar, a number of strains for fine/ carpet wool and mutton production have been evolved. These new strains of sheep were named as Avikalin, Avimans, Avivastra, Bharat Merino, Nali-Synthetic, Chokla-Synthetic, Nilgiri-synthetic, Patanwadi-synthetic, Awassi × Malpura, Garole × Malpura and Gaddi-synthetic. Merino type sheep were also evolved by inter-se mating of 75 per cent grade and stabilizing the exotic inheritance at this level through inter-breeding and selection for wool weight and quality. This strain has been named as Bharat Merino and is a substitute of exotic fine wool breed. Avikalin strain, evolved from Rambouillet × Malpura half-breds has a significant improvement in carpet wool production and quality and rams of this strain have been extensively distributed in Rajasthan, Uttar Pradesh and Haryana.

Crossbreeding experiments for improving mutton involved exotic mutton breeds, viz. Dorset and Sufflok with indigenous breeds, viz. Malpura, Sonadi, Muzzafarnagari, Nellore, Mandya, Deccani and Madras red and crossbreds shown improvement in meat production as reflected by improvement in body weight gains, efficiency of feed conversion and dressing percentage. Crossbreds evolved along with their genetic composition are presented in Table 1.7.

Crossbreeding for carpet wool production

Sporadic attempts for improving productivity of sheep through crossbreeding/upgrading were made even during the pre-independence period. Most of the earlier efforts were aimed at improving sheep for fine wool production through introducing exotic fine wool inheritance or up gradation using the indigenous improver wool or dual purpose breeds on limited scale. Though reasonable success was achieved in developing new

breed/strains like Hissardale, Kashmir Merino etc., on account of non continuity of efforts, the achievements could not be sustained to leave perceptible results. During the last 35-40 years, concerted efforts were made to evaluate the genetic architecture and production potential of some of the indigenous breeds as well as to take up development programme on regional basis which also have the limitations of wide variations due to sampling technique and population sizes involved.

The crossbreeding of extremely coarse and hairy breeds like Malpura with Rambouillet at CSWRI, Avikanagar has shown that half-breds from such crosses yield more wool of excellent carpet quality than native Malpura. The Avikalin strain evolved out of this crossbred base is able to produce about 2 kg greasy fleeces annually of 25-micron fibre diameter, 25 per cent medullation and about 4.5 cm staple length. The wool produced by Avikalin is superior to the carpet wool produced by indigenous breeds (Chouadhry and Chaudhary, 1991).

Improvement in wool yield and quality has also been observed in Avimaans and Awassi × Malpura crossbreds. Avikalin × Avimaans crosses are being upgraded with Avikalin as dual-purpose sheep (carpet wool and mutton production).

The crossbreeding experiments have given encouraging results and have shown substantial improvement in wool quality approaching the targets of ideal carpet wool. The crossbreeding of hairy breeds in Southern region of India with such mutton type breeds as Suffolk and Dorset have also shown appearance of fleece cover on the crossbreds. Similar trends are also exhibited by the synthetics evolved under AICRP unit of APAU, Palamner (Andhra Pradesh) using Nellore and Mandya local breeds (Chouadhry and Chaudhary, 1991).

Crossbreeding for improving wool production

Sporadic attempts for improving productivity of sheep through crossbreeding were made even during the pre-independence period. Most of the earlier efforts were aimed at improving sheep for fine wool production through introducing exotic fine wool inheritance or up-gradation using the indigenous improver wool or dual purpose breeds on limited scale. Though reasonable success was achieved in developing new breed/strains but on account of non-continuity of efforts and due to population sizes involved, the achievements could not be sustained to leave perceptible results.

Crossbreeding among native breeds

Among native wools, Chokla has the overall best performance for the functional characteristics of carpets followed by Magra, Jaisalmeri,

Malpura, Nali and Sonadi in the given order (Anonymous 1990). Limited research efforts have been made to achieve improvement in the wool yield and its quality among indigenous sheep breeds through upgrading the low producing local sheep with indigenous superior carpet wool breeds like Ckokla, Magra etc. The crossbreds of south Indian mutton breeds viz. Bellary at Hosur (Tamil Nadu) with north Indian improver Magra breed showed advantage in wool production and quality. Some improvement in local breeds of Madhya Pradesh and Uttar Pradesh were also observed when crossed with Chokla and Magra rams. Increase in greasy fleece weight and fibre length and decrease in fibre diameter and medullation percentage was reported (Chaudhry and Chaudhary, 1991). Bohra *et al.* (1993b) identified a new breed of sheep i.e. Kheri evolved under the field conditions in the migratory flocks by using Marwari/Jaisalmeri rams on local sheep.

Crossbreeding for fine wool production

Attempts of crossbreeding native sheep with exotic fine wool breeds for increasing wool production and quality have been made even during the pre-independence period. Many crossbreeding experiments for improving fine wool have been reported by Das and Rajgopalan (1956), Amble *et al* (1967), Amble and Malhotra (1968), Raina *et al* (1973), Acharya (1974), Chouadhry and Chaudhary (1991) and Singh and Singh (1998). In early 1900s superior indigenous sheep breeds were crossed with cape Merino, South Down, Romney Marsh, etc. in Maharastra, Uttar Pradesh, Mysore, Punjab, Tamil Nadu and new strains, viz. Hissardale, Nilgiri, and Kashmir Merino were developed. However, these programmes also suffered from lack of continuity. The results of the earlier crossbreeding experiments, though, were not very conclusive because of small number of rams used and non-availability of contemporary performance records, the experiments, in general, indicated the superiority of crossbreds over the indigenous breeds involved with respect to body weights, wool weights and quality traits. Further, survivability of the half breds was similar to that of native animals but the higher crosses exhibited higher mortality. These results also indicated that the Rambouillet/Merino crosses thrived better than those from the British breeds.

With the establishment of the CSWRI and launching of AICRP on Sheep Breeding, concerted efforts in this direction were made. Avivastra a new fine wool strain evolved through crossing of Chokla, Nali and Jaisalmeri sheep with Rambouillet/Merino, are capable of producing about 2.5 kg of greasy wool annually having fibre diameter of 21-22 micron, medullation percentage 15 and staple length 4.5 cm. They are

thus potential fine wool producing animals meeting the apparel quality characteristics. Avivastra has been upgraded and merged with Bharat Merino, a fine wool strain having 75% inheritance of Rambouillet/ Merino, as they did not differ significantly in growth and wool quality traits. Bharat Merino strain of sheep evolved by CSWRI and maintained in Kodai hills is capable of producing about 3.0 kg greasy wool annually with fibre diameter of 20.0 microns, staple length 7.5 cm and medullation percentage less than one. The Rambouillet and Merino crosses with Nilgiri at the Sheep Breeding Research Station, Sandynallah also exhibited potential to be evolved into a fine wool breed at 50 to 62 percent level of exotic inheritance.

There was substantial improvement in fibre diameter (35% to 14.0) and medullation percentage (37.0 to 3.0) as well as gain in body weights when the superior carpet wool breeds like Chokla and Nali were crossed with exotic fine wool breeds. There was, however little increase in wool yield, when crossed with fine wool breeds. The poor quality carpet wool breeds when crossed with exotic mutton/ dual purpose breeds resulted in improvement in weaning weights, greasy fleece weights as well as quality traits except staple length. The very coarse to hairy wool breeds, except in some cases produce medium quality carpet wools with about 25 to 35 micron diameter and 30 to 40 per cent medullation even in first cross (Chouadhry and Chaudhary, 1991; Singh and Singh, 1998).

During 1970s the Merinos have been imported mainly from Russia excepting some rams from Australia. Theses rams are stationed at Dhulia farm of Raymond Mills Ltd. in Maharashtra. The Raymond mills undertook a scheme of research and development for sheep breeding and wool production in India with a view to produce indigenously Merino type wool. The Company decided to discontinue the sheep development project due to strike.

The results indicate that almost all the crossbreds have shown improvement in wool quality but the staple length ranging between 3.5 to 5 cm at six monthly clip remains the limiting factor for which rigorous selection and/or appropriate shearing practices need to be developed to make the wool suitable for appropriate processing. Further, the results also suggest that increasing the exotic inheritance beyond 75% per cent gives little advantage. This however required the higher level of management and feeding input than the half-breds and native sheep.

Crossbreeding for improving mutton production

The All-India Co-ordinated Research Project (AICRP) on sheep breeding for mutton was started in 1971. Under this, experiments were conducted at 5 centres, viz. Avikanagar, Palamner, Makhdoom, Rahuri

and Madras. Dorset and Suffolk rams have been used to improve mutton sheep viz. Malpura, Sonadi, Mandya, Nellore, Muzaffarnagri, Deccani and Madras Red. The objective of the project was to attain 30 kg body weight at 6-month age of lambs. Through crossbreeding followed by inter-se mating and selection, Mutton Synthetic also known as Avimaans was evolved at Avikanagar, Mandya and Nellore Synthetics have been evolved at Palamner.

Avimaans (Mutton Synthetic) lambs could attain a body weight of 25 kg at 130 days of age with feed conversion efficiency of about 18 percent. Malpura lambs could also achieve this body weight with similar feed conversion efficiency through selection. Results showed that Avimaans lambs had potential for mutton production under intensive feeding system. However, Mutton Synthetic lambs have a tendency to deposit fat during terminal part of feedlot. Further the reproductive efficiency of this new strain was significantly lower as compared to that of Malpura sheep. Since reproduction is of utmost importance especially in breeding sheep for mutton production and reproductive efficiency of Avimaans strain was poor, it was decided to stop further propagation of this strain (Singh *et al.* 2006). Performance of Nellore and Mandya Synthetic is presented in Table 1.7. Nellore Synthetic rams were supplied to farmers through Field Demonstration Unit established in 1985-86. There was improvement in body weight of quarter bred lambs at all ages as compared to indigenous lambs in farmers flocks. Performance of Nellore Synthetic rams were comparable to that of Nellore rams in terms of fertility and sex libido.

The results of cross breeding on the whole, revealed that per cent improvement in body weight up to 6 months of age is conspicuous in different crossbreds over contemporary natives but only marginal improvement is observed at 12 months of age. This is indicative of the fact that crossbreds/new synthetics required high plane of nutrition and if they are managed on the same feeding regimen as for natives, the differences that were conspicuous up to 6 months age, narrow down gradually and become marginal at the age of one year. Due to non-availability of required plane of nutrition, mutton type strains developed by crossing Suffolk and Dorset with the indigenous breeds could not outdo the natives under village managemental conditions despite the improvement in body size as well as in wool quality and quantity.

To improve the growth rate as well as milk yield, the Awassi rams were crossed with Malpura ewes at CSWRI, Avikanagar and with Deccani at NARI, Phaltan. The significant improvement in crossbreds was observed over natives with respect to growth and milk yield (Nimbkar, 1995; Report, 1998; Narula *et al.* 1999).

Table 1.7 Sheep strains developed.

Genotype with utility / location	Parent breeds		Level of exotic inheritance (%)
	Indigenous	Exotic	
Bharat Merino, for fine wool CSWRI, Avikanagar	Chokla, Nali, Malpura, Jaiselmeri	Rambouillet, Russian Merino	75
Avivastra, for fine wool CSWRI, Avikanagar	Chokla, Nali	Rambouillet, Russian Merino	50
Nilgiri Synthetic, for apparel wool TNVASU Sandynallah	Nilgiri	Rambouillet, Soviet Merino	62.5-75.0
Patanwadi Synthetic for carpet wool GAU, Dantiwada	Patanwadi	Rambouillet, Soviet Merino	50
Avikalin, for carpet wool CSWRI, Avikanagar	Malpura	Rambouillet	50
Avimaans, for mutton CSWRI, Avikanagar	Malpura, Sonadi	Dorset, Suffolk	50
Indian Karakul, for pelt CSWRI, ARC Bikaner	Marwari, Malpura, Sonadi	Karakul	75
Kashmir Merino, for fine wool J &K State	Gaddi, Bhakarwal, Poonchi	Delaine Merino, Rambouillet, Soviet Merino	50-75
Hisardale, for apparel wool Haryana State	Bikaneri	Australian Merino	75

Results of crossbreeding Muzaffarnagri ewes with Dorset and Suffolk rams during 1979 to 1984 had shown little improvement as compared to improvement through selection. It was therefore, decided to improve Muzaffarnagri sheep for mutton production through selection. Male lambs maintained on feedlot after weaning at 60 days of age could achieve 25 kg body weight at about 120 days of age with average daily gain of 162 g and feed efficiency of about 20 per cent. In one of the experiments, male lambs in feed lot (from 91 to 180 days) could achieve an average live weight of 36.9 kg. Thus, Muzaffarnagri sheep has shown excellent promise for mutton production.

Some experiments on grading up were undertaken using breeds like Malpura and Bikaneri as improver breed in AP, Tamil Nadu and Bihar. The crossbreds of these native sheep exhibited faster growth rate in Bihar

but at other places the results were not perceptible (Chaudhry and Chaudhary, 1991). In 1997, Orissa Govt. purchased Malpura rams for distribution among farmer's sheep flocks. As per feedback received, the breeding rams supplied were performing well and the progenies born out are superior on body weight than their native counter parts (Das *et al.* 2001). From the available reports it is revealed that percent improvement in body weight up to 6 months of age is conspicuous in different crossbreds over contemporary natives but only marginal improvement is observed at 12 months of age.

Crossbreeding of sheep for pelt production

Improvement for pelt production was initiated with the importation of Russian Karakul sheep in 1975 in the country at CSWRI, Avikanagar and a strain Indian Karakul was evolved. Crossbreeding of Karakul with Malpura, Marwari and Sonadi breeds of sheep indicated that at half bred level 30 to 35% of the pelts fall under the jacket type. Further at the 3/4 level the proportion of jacket type pelts increased to more than 50-60%. The *size* and weight of the pelt also compares suitably with the pure Karakul pelts. The performance of Karakul was satisfactory with respect to production, reproduction, survivability and adaptation (Jain *et al.* 1998). But due to socio-political reasons the programme was phased out.

Crossbreeding for increasing prolificacy

Considering the importance of multiple births in sheep breeding in special reference to mutton production, Garole a prolific breed of sheep has been introduced at CSWRI, Avikanagar in 1997. The results indicated that twining percent in Garole X Malpura (GM) half-breeds ewes were 52.74 % and lamb born, as triplets were 7.46 %. The average number lambs born per ewe lambed was 1.64 in GM and 1.08 in Malpura sheep (Kumar *et al.* 2004). The overall percent gain in prolificacy in GM was 52.38, which increased to 75.73 in third parity (Mishra *et al.* 2006). The GM compared to M ewes also weaned more lambs per ewe lambed (1 vs. 1.41). It was observed that the body [illegible] at different ages of GM half bred were on little lower side [illegible] contemporary Malpura lambs. The survivability of G X M [illegible] at par with native Malpura sheep (Mishra and Arora, [illegible] 2004). Similar study was also carried out at [illegible]rch Institute, Phaltan (Maharashtra) using [illegible]bkar, 1995, Nimbkar *et al., 2000)*. [illegible]rossing with Garole reduces [illegible]red with Deccani but

lambs sired by Garole rams were more resistant to naturally acquired gastro-intestinal nematode infections and to artificial challenge with *Haemonchus contortus* than those sired by Deccani or Bannur rams.

In general, crossbreeding work conducted in the country indicated the superiority of half-breds in body weight, GFY and fleece quality over the indigenous breeds involved except for Polworth crosses with Rampur Bushair in Uttar Pradesh. The survival of half-breds was similar to that of indigenous breeds, but crosses containing higher exotic blood did show problems of survival. Rambouillet appeared to be superior to other exotic breeds. When more than one indigenous breed was used with the same exotic breed, carpet wool breeds - particularly Magra showed superiority. The performance of progeny produced from interbreeding half-breds was not much inferior to that of the first generation (F1) half-breds.

Development of New Strains

In the recent years, the CSWRI developed new strains of sheep through crossing the indigenous animals with exotic breeds. The Avikalin sheep have the potential of producing about 2 kg greasy wool annually with fibre diameter of about 25-30 microns, medullation percent around 25 and staple length of about 4.5 cm. Avikalin, Avimaans, Avikalin x Avimaans and Awassi × Malpura sheep not only produce more wool of better quality in comparison to native Malpura but also weigh heavier at all ages. Similar trends are also shown by the Synthetics evolved by AICRP unit of Palamner using Nellore and Mandya local breeds (Singh *et al.*, 2006).

Integrated sheep and wool development project

The ministry of textile has started a pilot project, the Integrated Sheep and Wool Development Project, in the year 1991-92. It covers the aspects of breed improvement, health coverage, production development, marketing assistance and training to sheep breeders in sheep husbandry and productivity. The programme has been extended to all major wool producing States.

During 1999-2000, the Board has made a provision to cover 2 million sheep under the scheme with an allocation of ₹ 26 million. By January 2000, 1.825 million sheep are being covered under 30 projects and 0.4 million sheep under new projects with an allocation of ₹ 13.1 million.

2.

Breeds of Sheep

The import of different breeds of sheep started in nineteenth century. At that time South Down and Cape Merino were imported in small numbers. Romney Marsh and Merino sheep were imported in Uttar Pradesh, Punjab and Karnataka in the beginning of twentieth century. Cross breeding of Deccani sheep with Merino rams was started in 1938. Some Cheviot, Border Leicester and Merino sheep were imported in 1940. Rambouillet and Dallen Merino sheep were imported in Jammu and Kashmir from USA in 1951. Cross breeding with these gave encouraging results, therefore Merino, Rambouillet, Corriedale, Polworth, Somalia, South Down, Soviet Merino etc., were imported. The details of some exotic, native and crossbred sheep are given below:

Exotic Breed

Dorset: This breed is found in England. It is good for mutton production. It is medium sized breed. The males have curved horns but females are polled. Their ears, legs and face are white and skin and lips are pink in colour. A sheep yields 2.5 to 3.5 kg wool annually. Fiber length varies from 7 to 10 cm. The wool is white and rough. The animals are shorn once in a year. The growth rate of lambs is good. Good pastures are necessary for their growth.

Suffolk: This breed is found in Great Britain. This is also a cross, which is good for mutton production. Their face, ears and legs are black in colour. Male and female are polled. Adult females and males weigh 70 to 100 and 100 to 135 kg respectively. Their legs are short and straight. The growth rate is high in this breed. Yearly wool production varies from 2.0 and 3.0 kg. Staple length is 5 to 6 cm. The wool is white but may be black in some places.

Corriedale: This breed is found in Australia and is good for mutton and wool production. This is a cross between Merino and Lincoln. The legs are short and the body heavy, wool is lustrous and of medium quality. The fiber length varies from 8 to 12 cm. Yearly wool production per sheep is 2.5 to 3.5 kg. They are white in colour but may have black

spots. The head is of medium size. Both sexes are polled. The adult males and females weigh 80 to 110 and 60 to 75 kg, respectively (Hultz, 1943; Link, 1942).

Rambouillet: This breed was developed from Merino in France. It is very sturdy breed and can adapt itself in different types of climates. If fed well, it can produce good quality wool. Its body is heavy and head is carried high. The rams have horns but the ewes are polled. They have wool on face and legs, their skin is pink in colour and ears are small. Adult females and males weigh 65 to 95 and 100 to 120 kg, respectively. Annual wool yield per animal is 4.5 to 5.5 kg. Staple length is 5.5 to 7.5 cm. Lambs at birth weigh 3.2 to 4.5 kg. (Lagrix, 1949).

Corriedale: This breed is found in Australia and is good for mutton and wool production (Fig. 2.2). This is a cross between Merino and Lincoln. The legs are short and the body heavy, wool is lustrous and of medium quality. The fiber length varies from 8 to 12 cm. Yearly wool production per sheep is 2.5 to 3.5 kg. They are white in colour but may have black spots. The head is of medium size. Both sexes are polled. The adult males and females weigh from 80 to 110 kg and from 60 to 75 kg, trespectively (Hultz 1943; Link 1942).

Karakul: The origin of this breed is in South Central Asia. It got its name from a village of the same name in USSR. The rainfall is scanty and fodder production is less in this area. The sheep are reared for pelt production. This breed is not good for wool or mutton production. Adult females and males weigh 60 to 70 and 80 to 100 kg, respectively. The neck is long, the body thin, hindquarters are high, the ribs are not wide spread and they have fat deposit at the base of their tails. The males have horns but the females are polled. The wool is inferior which may be black or white or brown in colour, which is used for carpet making. Yearly wool yield per animal is 3.7 kg (Florich, 1931).

It has been bred with Marwari, Malpura and Sonadi breeds of Rajasthan for developing it as mutton breed (Singh and Pant, 1995; Mehta *et al.* 1995 and Sabani *et al.* 2007). The average body weight of Karakul, half breds and ¾ crosses diffentiated from 3.5, 3.09 and 3.4 kg at birth to 22.04, 25.25 and 23.26 kg at 12 months, respectively (Sahani *et al.* 2009).

Awassi: It is known as Baladi or Syrian. This breed is native of Syria and is also found in Central and West Iraq. The wool is rough and the breed is good for milk and mutton production. The sheep can yield 40 liter milk in one lactation. Males and females on an average produce annually 2.50 and 1.75 kg wool, respectively. The sheep of this breed are found in Central East Asia have fat on their humps. Their face is

black and may be brown also. Only males have horns (Hirsch, 1933; Schuler, 1937).

Ossimi: It is found in Egypt. It has a fat deposit on its hump. The wool may be white or brown in colour. Adult sheep weigh from 45 to 55 kg. The annual wool yield per sheep varies from 1.4 to 1.8 kg (Sedky, 1948).

Cheviot: This breed is found in Scotland. Nothing definite can be said about its origin (Frazer, 1948). It is good for mutton production. Both sexes have horns. This breed has some blood of Border Cheviot (Phillips, 1947). This breed is small with erect ears, a clean white face and white legs, covered with white hair. In contrast, the nose, lips and feet are usually black in colour. It has a light fleece weighing approximately 2.5 to 3.5 kg containing certain percentage of grease along with suint (jointly termed as 'yolk'). The fleece is also comparatively less shrinking.

Barbary: This breed is found in Libya, Tunisia and Eastern Algeria. The wool is rough and the breed is good for milk and mutton production. The wool is white in colour but may be black and brown also. Only rams have horns. The lambs at birth weigh 2.5 to 3.0 kg. Adult rams and ewes weigh 40 to 45 and 35 to 40 kg, respectively. The wool is white. The sheep produce two lambs in one year or 3 lambs in two years. The ram produces 4.0 to 5.0 kg wool annually (Andreoni, 1938; Pissaloux, 1943).

Border Leicester: This breed was produced by crossing Cheviot with Liecester. It is found in Southern Scotland and Northern England. The wool is of medium quality. Both the sexes are polled (Young, 1950).

Clunforest: This breed is found in England and is good for mutton production. Horns are absent. The average birth weight of lambs is 3.2 kg. Adult rams and ewes weigh 74 to 86 and 55 to 62 kg, respectively. The annual wool yield is 3.4 to 3.7 kg. The average staple length is 7 to 8 cm (Builow and Dzhadaridze, 1975).

Kurdi: It is found in North Eastern part of Iran. The wool is rough and the breed is good for mutton production. Head and legs are black. Some sheep may have black and brown colour. Only rams have horns.

Waziri: This breed is found in North West Frontier region of Pakistan. It is good for mutton production. The ears are long (Lal, 1947).

South down: This is one of the oldest English breeds. It is short stature and stocky in appearance. Its head is a broad with light brown face. The fleece obtained normally weighs between 2 to 3 kgs.

Leicester: The sheep belonging to this breed are medium stature with clean face and legs producing long wool. Body conformity is identical to the long woolled breeds.

Lincolon: It is a large sheep with a broad head and large thick ears. It produces long and good quality wool with a fleece weight of 5 to 7 kgs. This is also suitable for cross breeding.

Romney Marsh: The other significant breed which must find a mention here is Romney Marsh which form the major chunk of sheep population in New Zealand in addition to Corrriedales which is also used for cross breeding in comparative smaller way.

Genetic Resources of India

India has 44 descript breeds of sheep and more in process of identification and documentation (Nivsarkar and Gupta 1998). A sizeable population is nondescript due to indiscriminate breeding and intermixing of breeds. There are no breed societies or agencies to register animals of a particular breed, maintain flock book and purity of breed or type. Very little effort for selection for developing these breeds has been made. Most of the breeds are very well adapted to harsh climate, long migration, tropical diseases, poor nutrition and shortage of drinking water and its poor quality.

The sheep breeds can be classified on the basis of agro-ecological regions viz. a) North temperate region, b) North Western arid and semi arid region c) Southern peninsular region and d) Eastern region. The breeds of sheep of these regions are presented in Table 2.1. They are also classified on the basis of major product i.e. a) apparel wool b) carpet wool, c) meat and carpet wool and d) meat types. Of the breeds of sheep, Marwari in northwest and Deccani in Southern-Central peninsula are numerically the most important and contribute largely for carpet wool and meat production.

Native and Crossbreds

Different types of climates are found in our country. The highest rainfall is found in one part and no rainfall for several years in another part of this country. The atmospheric temperature is several degrees below freezing point in some parts and it may reach as high as 50° C in other parts. The country may be divided into four regions on the basis of climate and sheep rearing practices. (Acharya, 1982).

These are North Temperate Region, Arid Western Region, Eastern Region and Southern Plateau Region

Northern temperate region

This includes Jammu and Kashmir, Himachal Pradesh and Uttara Khand. The climate is predominantly temperate with the high ranges experiencing snowfall in winter and remaining lush green in summer.

Table 2.1 Breeds of sheep in different agro - ecological regions in India and their major products

North Temperate	North Western Arid and Semi Arid	Southern Peninsular	Eastern
Karnah (AW)	Hissar Dale (AW)	Nilgiri (AW)	Bonpala (MCW)
Kashmir Merino (AW)	Jaisalmeri (MCW)	Coimbatore (MCW)	Balangir (MCW)
Gaddi (CW)	Jalauni (MCW)	Bellary (MCW)	Chottanagpuri (MCW)
Gurez (CW)	Kheri (MCW)	Kanguri (M)	Ganjam (MCW
Changthangi (CW)	Muzaffarnagri (MCW)	Kilakarsal (M)	Tibetan (CW)
Bhakarwal (CW)	Malpura (MCW)	Madras Red (M)	Garole (M)
Poonchi (CW)	Marwari (MCW)	Mandya (M)	
Rampur Bushair (CW)	Pugal (MCW)	Mechheri (M)	
Biangi (AW)	Sonadi (MCW)	Daccani (M)	
	Nali (CW)	Nellore (M)	
	Pattanwadi (CW)	Ramanad White (M)	
	Magra (CW)	Tiruchy Black (M)	
	Chokla (AW), Lohi(CW)	Vembur (M)	
		Hasan (M)	
		Tenguri (M)	

NB: AW is Apparel wool; CW is Carpet wool; MCW is Meat and Carpet wool and M is Meat.

In lower altitude areas the summers are hot and winters are cold. Monthly mean temperature is around 10 ^{0}C. Excluding the cold desert area, the annual rainfall of the region ranges from 75 to 175 mm. The main soil types of the region are skeletal soils of cold region, podsolic soils, mountain meadow soils and hilly brown soils. Being hilly area lands of the region have steep slopes in undulating terrain (Khanna, 1989). The forest cover in the region in 1991 according to satellite imagery (NRSA, 1989) was 40%. The forest area in Jammu and Kashmir and Himachal Pradesh is much less as compared to Uttara Khand hills. The productivity level of all crops is lower than the all India average and the annual growth rate is much less. The cropping intensity is around 130%. Nearly half of the rural population, especially in middle and upper Himalayan regions are nomad pastorolists. In fact, the highest concentration of nomad pastorolists is found in this region. Dense forests are found in this area. Good quality grasses grow under trees from March to November. In April, 27 and 87% flocks go on

migration in Himachal Pradesh and Uttara Khand, respectively. One or two family members take the flock for grazing. Animals are not given supplemental feeding in addition to grazing. About 60% of the sheep are sheared thrice and the rest only twice. The prominent breeds of this region are:

*1. **Bhakerwal:*** It drives its name from a tribe of the same name. It is found in the districts of Udampur and Rajauri Tehsil of Jammu & Kashmir. They are heavy but good in climbing mountains. They weigh 28 to 35 kg. The ewes are polled but rams have horns. The wool is white but may be coloured sometimes. They are shorn thrice in a year. Annual wool production per sheep varies from 1.5 to 2.0 kg. The fiber length varies from 10 to 15 cm and the diameter is 37μ. The wool is of 40's count (Lal, 1947).

*2. **Biangi:*** It is found in Kangra, Lahul and Spiti districts. It resembles Gaddi. It is short in size and reared for wool and mutton. Its wool is used for making garments. They can tolerate cold climate very well.

*3. **Gaddi:*** This is also known as Bhaderwa. It is found in the districts of Hamirpur, Kangra, Lahul and Sipti and Rampur Bushair of Himachal Pradesh, Bhaderwa Tehsil of Jammu & Kashmir and districts of Dehradun, Nainital, Tehri and Garhwal of Uttara Khand. The sheep, on an average weigh 21 to 30 kg. The height of these sheep is short and can climb mountains with ease. Rams have horns but the ewes are polled. Their ears are long, the tail is thin and of medium length. Their face is brown. They give birth to single lambs, but 15 to 25% sheep give birth to twins. They can be milked up to 3 months. Average staple length is 6 cm and fiber diameter 25 to 30μ. They are shorn thrice in a year.

*4. **Kashmir Valley:*** Its height is short, wool is colored and of inferior quality.

*5. **Gurej:*** It is found in Gurej tehsil of Kashmir. They are white in colour but some may be brown or black or brown with black spots. This breed is found mostly at high altitude of 2400 meter and above. This is a heavy sheep. The ears are short and tail is thick. It is shorn twice in a year. This breed is good for milk production. The wool is hairy and rough. Annual wool yield per animal is 1.3 to 1.8 kg. The fiber may reach length up to 15.0 cm.

*6. **Rampur Bushair:*** This breed is found in the districts of Mahasu, Lahaul and Spiti, Shimla, Nahan, Solan, Kinnaure and Bilashpur of Himachal Pradesh and districts of Dehradun and Rishikesh and Nainital of Uttara Khand. The average temperature of this region varies from– 30 to 37 ^{0}C. The annual rainfall of this region is 149 mm. The animals are strong and well built and medium sized with a square body. The

average body weight of adult rams is 34.73 ± 0.45 kg and that of ewes is 25.98 ± 0.49 kg. Their face is Roman nose and ears are long, with prominent mid ridge, the rams have horns which turn backward and downward and the ewes are polled. Their wool is white but may have brown or black spots. It is of medium quality. The wool is absent from legs, face and belly. Annual wool production per sheep is 1.3 to 1.9 kg. The fiber length varies from 15 to 23 cm and diameter from 27 to 35μ. The medullation is 25 to 30 per cent (Dixit *et al.,* 2005).

*7. **Karnah:*** It is found in Karnah tehsil of Kashmir. This is a hardy sheep and can adopt itself to rigorous climatic conditions. They weigh from 28 to 38 kg. The horns of the rams are curved but ewes are polled. Their wool is of good quality but of shorter fiber length. They are shorn twice in a year. Annual wool yield per sheep is 1.0 to 1.5 kg. Their staple length is 4 to 6 cm and fiber diameter is 28 to 32μ. It is of 58 to 60's count.

*8. **Punchi:*** It is found in Punch and Rajauri districts of Jammu & Kashmir. It resembles Gaddi but its height is more. They weigh 25 to 30 kg and the horns are absent in both the sexes. The ears are of medium length and the tail is thin and short. The wool quality varies from medium to high and is white. They are shorn thrice in a year. The annual wool production per sheep varies from 1.4 to 1.6 kg. The fiber length varies from 14 to 15 cm and diameter is 26μ.

*9. **Changthangi:*** It is found in Changthang region of Ladakh. It is also called Ladhaki. They are sturdy and have wool all over their body. They weigh from 28 to 36 kg. The wool is good for apparel making. They are shorn twice in a year but at places, they are shorn annually. The annual wool yield per sheep varies from 1.0 to 1.5 kg.

*10. **Kashmir Merino:*** This breed was evolved by crossing Gaddi, Bhakerwal and Punchi sheep with Russian Merino and Rambouillet rams. They have 50 to 75 per cent exotic blood. Annual wool production per sheep varies from 2.0 to 2.5 kg. The staple length varies from 12 to 16 cm and fiber diameter is 20μ.

Arid western region

This region includes Punjab, Haryana and plains of Uttar Pradesh, Rajasthan, Madhya Pradesh and Gujarat and has the second largest sheep population (15.42 million). Sheep from Rajasthan migrate to Uttar Pradesh, Madhya Pradesh and Haryana. The sheep from Rajasthan usually go on migration in November and return by the beginning of rainy season. The sheep of this area produce mostly coarse carpet quality wool, except Chokla and Patanwadi, which produce medium fine wool. The major breeds found in this region are:

1. Chokla: This is also known as Chhaper and Shekhawati. It is found in Churu, Jhunjhunu and Sikar districts and parts of Bikaner, Nagaur and Jaipur districts. It is also called Merino of Rajasthan. The average body weight of rams and ewes is 35.0 and 23.1 kg, respectively. The tail is thick and sheep are medium in height. The ears are of medium length. (7.77 ± 0.09 cm) and tubular. Both the sexes are polled. The age of maturity for male and female lambs is 15 and 18 months, respectively. The wool is of medium quality and is good for carpet and apparel making. The adults on an average yield 2.75 kg wool per annum. The average staple length is 4.7 cm, diameter 28μ and medullation 24 percent. The wool is of 54 to 60's count. The wool shorn after rainy season is yellow. Milk production is less. They give birth to one lamb at a time (Bhasin and Desai 1965; Arora *et al.,* 1975 c; Mathur, 1977; Tomar and Singh 2003).

2. Pugal: Its name has originated from Pugal region of Bikaner district, its home tract. It is found in Pugal region of Bikaner and in Northern parts of Jaisalmer district. Its face is black and have yellow band running from eyes towards nose. The tail is short. The age at maturity in case of male and female is 15 and 18 month, respectively. The average body weight of adult males and females is 31.8 and 27.0 kg, respectively. The wool is white and of medium quality. The annual wool production varies from 1.4 to 2.3 kg. Average staple length is 5.7 cm, fiber diameter 35μ and medullation varies from 80 to 86% (Acharya, 1982).

3. Marwari: Driving its name from its home tract in Marwar, the breed resembles black headed Persian sheep but is of small size and has good fleece yield. It is found in the districts of Jodhpur, Pali, Nagaur and Sirohi. It is also found in the adjoining districts of Udaipur, Ajmer, Bikaner and Jaisalmer. Average body weight of rams and ewes are 30.7 and 26.2 kg, respectively. The face is black, ears are small, tail is thin and of medium size. Male and female lambs mature at the age of 12 and 18 months, respectively. They are not good for milk production. Average wool yield per animal per annum is 1.33 kg. (Dass and Singh, 2001). The staple length in 6.6 cm average fiber diameter is 36.93μ and medullation percentage is 65.2. The wool is of 46 to 50's count.

4. Jaisalmeri: Driving its name from its home tract at Jaisalmer. In addition to Jaisalmer district, it is also found along the western border of Jodhpur and Barmer districts. It is the tallest of all the breeds found in Rajasthan. The average body weight of ewe varies from 33 to 36 kg. The face is black but sometimes may be brown also. Its ears are long and horns are absent in both the sexes. Male and female lambs mature at the average age of 16 and 18 month, respectively. Annual wool yield

per sheep is 1.5 kg. The average staple length is 6.5 cm, fiber diameter 39.1μ and medullation 56.1 percent. The wool is of 52 to 54's count. It is the largest breed of Rajasthan.

*5. **Magra:*** Formerly known as Bikaneri, is also known as Bikaneri Chokla and Chakeri. It is found in Churu, Nagaur and Bikaner districts. The average body weight of adult rams and ewes is 26.84 and 24.6 kg, respectively. Its face is white and has short brown circle around the eyes. The skin colour in pink. The tail is of medium length and horns are absent in both the sexes. The wool is lustrous, white and of medium quality. Annual wool yield per animal is 2.18 kg. The average staple length and fiber diameter are 5.8 cm and 32.45μ, respectively. The medullation percentage is 48.3. It is shorn thrice. The breeding programme involves improving this breed through selection; however, there is much crossing with other breeds in the vicinity. (Mehta et al., 2000).

*6. **Nali:*** This breed is found in the districts of Ganganagar and Churu and in the northern parts of Jhunjunu district of Rajasthan and Hisar and Rohtak districts of Haryana. The average body weight of rams and ewes is 34.6 and 24.3 kg, respectively. They are of medium size, the face is brown and covered with wool. The ears are long and the legs are short. The rams and ewes of this breed mature at the age of 12 and 18 month, respectively. The wool is present on head, abdomen and legs. The wool is pale yellow in colour. The annual wool yield per animal is 2.29 kg. The fibre density per square cm is 271.3. The average staple length is 7.4 cm, fiber diameter, 34.9μ and medullation 45 to 50 percent. The wool is of 42 to 50' s count (Arora *et al.,* 1975 c).

*7. **Sonadi:*** It is found in Udaipur district of Rajasthan and northern parts of Gujarat. The average body weight of ram and ewe is 38.6 and 21.2 kg, respectively. Its face is white and neck is light in colour. Their tails are thin and long. It is quite tall. The ears are long. Male and female lambs mature at the age of 12 and 16 month, respectively. They are also milked and good for mutton production. The wool is absent from legs and abdomen. Annual wool yield per sheep is 0.90 kg. The average staple length, fiber diameter and medullation percentage are 4.98 cm, 52.7μ and 8.16, respectively. It is of 30 to 36' count (Arora *et al.,* 1977).

*8. **Malpura:*** Though very similar to Sonadi, it is better in wool production and quality and in body size probably due to better environmental and nutritional conditions in the Malpura tract in comparison to that in the home tract of Sonadi. This breed is found in Jaipur, Tonk and Sawaimadhopur districts and parts of adjoining districts of Ajmer, Bhilwara and Bundi. The breed got its name from a tehsil of the same name in Tonk district. The average adult body weight

of the rams and ewes are 41.6 and 24.5 kg, respectively. The frame of breed is strong, the face is light brown, tail is thin and long and ears are short. Both the sexes are polled. The male and female mature at the age of 10 and 16 month, respectively.The age at first service, weight at first service, age at first lambing, weight at first lambing and lambing interval are 649.42±112.99days, 27.73±0.20 kg, 810.79±14.32 days, 28.09±0.30 kg and 372.58±5.15 days, respectively (Arora and Swarnkar, 1995). The wool is white and of inferior quality. A sheep may yield 21.0 kg milk in a lactation of 90 days. The average staple length is 6.5 cm, fiber diameter 51.4μ and medullation 84.1 percentage. The wool is of 30 to 35's count (Arora *et al.,* 1975 a).

*9. **Kheri:*** It is a newly developed strain due to the cross breeding of Marwari rams with local sheep located in their migratory route such as Pali, Jodhpur, Nagore, Ajmer,Tonk, Swaimadhopur and Karoli. Their face is black. Black spots are found around eyes and white lines are found on forehead. Their average weight of adult rams and ewes is 35-40 and 26-30 kg. Their wool is white in colour. The average annual wool production 1.283±0.012 kg (Sharma *et al.,* 2003). The fiber length, fiber diameter and medullation are 5-7cm, 35-40μ and 60-70 per cent, respectively (Tomar and Singh 2003).

*10. **Patanwadi:*** This is also known as Kuchhi, Deshi Vadhiyari, Kadhiawadi and Charotry. The breed includes 3 district strains (i) non migratory, red faced animals with small bodies, yielding relatively finer fleeces. These are typical Patanwadis and are located in Northeastern Sarasota;(2) the migratory type with larger body and long legs, typical Roman nose and long tubular ears. This variety, producing coarser fleeces, is found in western and northern Gujarat (3) the meat type, with big body, low stature and coarser fleeces, found in southeastern region of Saurashtra and Kutch districts and sandy loam areas of Patana Kadi Kalol, Sidhapur and Chanssamme taluks of Mehsana district of Gujarat. The average body weight of adult rams and ewes is 33.34 and 25.53 kg respectively. The legs are long and are of medium size. Its face is brown, ears long, neck short and tail thin and short. It gives milk up to 3 months of lactation. The wool is white in colour and of medium quality. Average wool production is 1.0 kg per sheep per annum. Average staple length, fiber diameter and medullation percentage are 8.5 cm, 40.0μ and 29.9 percentage, respectively.

*11. **Lohi:*** This breed is found in Ferozepur and Amritsar districts of Punjab. It has a good height. Its head is big and brown in colour. The tail is thick and short, udder well developed, teats long. It usually gives birth to one lamb but twins are also not uncommon. Though its wool is thick and long, it is one of the best breeds of Asia for milk and

mutton. The average body weights of rams ranged from 50 to 83 and that of ewes from 35 to 55 kg. Ram lambs are sold at the age of 8-10 months, when they weigh around 35 kg (Khushwala *et al.,* 2000).

12. Jalauni: It is found in Jalaun and Jhansi districts of Uttar Pradesh. Average body weight of sheep varies from 28 to 32 kg. Their height is average, nose flat, tail thin and of medium length and ears are long. They are usually white but may have black or brown spots on face and around eyes. The wool is inferior and of short staple length. It is absent from belly and legs. They are milked and are good for mutton. Annual wool production per sheep is 2.0 kg. Average fiber diameter is 41μ.

13. Muzzafarnagari: It is also known as Bulandshaheri. It is found in Saharanpur, Meerut, Bijnaure and Muzafarnagar. The animals are medium to large in size. Face and body are white with patches of black and brown. Ears and face is black. Ears are long. The wool is coloured and inferior. They are polled.

14. Munjal: This breed was developed by crossing Nali with Lohi in Patiala and Bhatinda districts of Punjab, Ambala, Karnal and Hisar districts of Haryana and Ganganagar district of Rajasthan. This breed is good for mutton production. The body and head are long. The colour of the face is light or dark brown. The tail is 35-40 cm in length. The legs are sturdy and long. The adult rams and ewes weigh 50-80 and 35-55 kg, respectively. Their wool is coarse and white in colour. The annual wool production per sheep varies from 2.2-3.2 kg. The fiber length, fiber diameter and medullation are 8-11cm, 48-55μ and 60-67 per cent, respectively (Tomar and Singh 2003).

15. Avikalin: This breed has been evolved by crossing Malpura with Rambouillet rams at Central Sheep and Wool Research Institute, Avikanagar, Rajasthan. The overall weight at 12 months of age is 24.9 kg. This breed is good for carpet making. Rams may or may not be horned. Wool is lustrous and soft. The average adult Annual wool production per sheep is 1.587 kg. The wool is absent from face but present on legs and abdomen. Average staple length, percent medullation and fiber diameter are 4.4 cm, 24.79 and 24.6μ, respectively (Anon, 1976, Singh *et al.,* 2006).

16. Avivastra: It has been produced by crossing Chokla with Rambouillet rams. The average body weights of rams and ewes vary from 40 to 50 and 35 to 45 kg, respectively. Average unwashed wool production is 2.4 kg per sheep per annum. Average staple length, fiber diameter and medullation percentage are 5.0 cm, 20μ and 21, respectively (Mani Mohan *et al.,*1979).

17. Hisar dale: Crossing Bikaneri with Australian Merino rams at Government Livestock Farm, Hisar, evolved it. Animals are small with

short legs, giving them a low set appearance. Colour is predominantly white, although some brown or black patches can also be observed. Average body weights of rams and ewes are 55 to 60 and 33 to 37 kg, respectively. Its lips are thin, nose pink and ears triangular and hanging. They may or may not be horned. The wool is of superior quality. Annual wool production per sheep is 2.3 to 2.8 kg. Average staple length, fiber diameter and medullation percentage are 6 to 10 cm, 24μ and 0.0, respectively. It is of 58' s count (Nanda, 1947)

18. Bharat Merino: It has been evolved at the Central Sheep and Wool Research Institute, Avikanagar for fulfilling domestic requirement of fine wool and using the breed as substitute of exotic fine wool breeds of the temperate countries. The strain has got 75% exotic inheritance of Rambouillet/ Russian Merino and 25% fine/coarse carpet type native sheep breeds Jaisalmeri, Chokla, Nali and Malpura. In addition to fine wool production, Bharat Merino sheep is an efficient converter of poor quality roughage into good quality mutton.

Average body weight at 12 months of age is 30.6 kg in semi-arid climate of Rajasthan. Bharat Merino breed could be successfully reared up to 6-months of age to attain best salvage value by slaughtering them for fulfilling domestic and external requirement of demand for mutton, which is additional to greasy fleece yield (0.90 kg), obtained in 1st shearing (about six months of age). The over all least square means for annual greasy fleece yield is 2.05 kg. Performance of Bhart Merino sheep with respect to production, reproduction and adaptability is significantly higher in sub temperate climate of Mannavanur than semi arid climate of Avikanagar (Singh *et al.,*2006).The breed can be reared in the Indian climate ranging from extremely hot (Rajasthan) to cold climates (Kodai Kanal hills of Tamil Nadu). A sheep farmer can enhance his income by rearing Bharat Merino lambs for mutton up to six months of age. Bharat Merino can also be reared for apparel wool production. Average annual greasy fleece yield was 2.44 kg. (Mehta *et al.,* 2000).

Eastern region

This includes Bihar, Bengal, Orissa, Assam, Arunachal Pradesh, Mizoram, Manipur, Tripura, Meghalya, Sikkim. Severe soil erosion in the hilly regions and regular flooding is main problems of this region. This region had high rainfall and high forest cover 58.2% in 1991 as per satellite imagery (NRSA, 1989). Rainfall being very high and of severe intensity on these hilly sedimentary soil mass, causes dispersal of soil particles. Climate varies from near tropical in the plains to alpine in high hills. The mean yearly rainfall ranges from 130-1200 mm. Despite the fact that the agro-climatic conditions in the hilly region of this one

are most ideally suited for livestock farming, unfortunately, this sector remains underdeveloped. Most of the flocks of plains go on migration. Flocks of hilly areas migrate to heights. Flocks start migrating in Sikkim with the onset of summer season and return with the onset of rainy season. The important breeds of this area are given below.

*1. **Balangir:*** It is found in Balangir and Sambalpur districts of Orissa. Their weight varies from 18 to 20 kg. Their ears are small. Horns are present in rams only; legs and belly are devoid of wool. Their wool is white or brown but may be black sometimes and is rough.

*2. **Bonpala:*** It belongs to Sikkim. They are very high, weigh 33 to 60 kg and their face is white or black in colour. The wool is white, rough and absent on belly and legs. The fleece colour ranges from complete white to complete black with a number of intermediary tones. A sheep produces 1.5 kg wool annually, whose fiber diameter varies from 28 to 35μ and medullation 77 to 84%. They go on migration (Katiyar *et al.,* 1981).

*3.**Tibetan:*** It is distributed in Northern Sikkim and Kameng district of Arunachal Pradesh. These are medium sized animals, mostly white with black or brown face and brown and white spots on body. Both sexes are horned. The nose line is convex. The ears are small broad and drooping. The fleece is relatively fine and dense. The belly, legs and face are devoid of wool. The wool is lustrous. The fleece colour is mostly grey, sometime with black spots. The fleece is extremely coarse, hairy and open.

*4. **Chhotanagpuri:*** This breed is found in Chhotanagpur, Ranchi, Sinhbhoom, Palamau, Hajaribag, Dhanbad and Santhal Pargana districts and parts of Bankura district of West Bengal. They are small in size (15 to 20 kg). Ears are small and legs are thin, but the tail is short but thick. They are polled and their wool is rough, inferior, gray or brown in colour. The wool production is 0.2 to 0.5 kg per animal per annum. The fiber diameter is 50μ and medullation is 80%.

*5. **Ganjam:*** It is native of Phulbani and Koraput districts of Orissa. It is of medium size and weighs 20 to 28 kg. They may have spots on body and face. It has hair on its body and good for mutton production. Only rams are horned.

*6. **Shahbadi:*** It is found in Patna, Gaya and Shahbad districts of Bihar. They weigh 20 to 27 kg. Their ears are short but tail is long. They don't have horns. They are of medium size, with long legs and have spots on their bodies. Annual wool production per sheep is 250 g. The wool is hairy and medullation is 80 to 85%.

*7. **Garole:*** They are distributed in Sunderban region of West Bengal in India. The breeding tract of Garole falls in 24 Parganas district of

West Bengal under the coastal saline zone of West Bengal. It is a very prolific breed known for twins, triplets and quadruplet births. Only male have horns. Marginal farmers and landless laboures maintain them. Average flock size ranges for 3 to 5. Average adult weights in male and females are 15 and 12 kg, respectively (Saha *et al.,* 2001). They breed round the year with two lambing peaks between December to February and August to September. Age at first lambing is 14 to 18 months. The lambing intervals of 205±2.23 days was reported by Bose (1996). The percentage of single, twin, triplet and quadruplet births is 41.63, 43.35, 14.18 and 0.21, respectively (Bose, 1996). The colour is generally white; some animals of black or brown colour are also seen. The height at withers, body length, heart growth and pouch girth is 50.7±0.79, 49.5±0.90, 58.8±0.93 and 56.5±1.15 cm, respectively in males and 45.3±0.37, 47.8±0.58, 60.1±0.63 and 62.7±0.70 cm, respectively in females. They are reared for mutton production. They are good milkers and rear twins without any problems. Average annual wool production is 150g. Their staple length, fiber diameter and medullation are 5.09 cm, 67.8μ and 75.17 per cent, respectively (Sharma *et al.* 1999).

Southern plateau region

It encompasses Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. About 20% sheep of this area go on migration. They are not given concentrate in addition to grazing, but occasionally they are given groundnut leaves. Peaks in heat are observed between May and August and November and February. The prominent breeds of this region are given below.

1. ***Bellari:*** It is found in the districts of Dharwar, Raichur and Bellari of Karnataka and Kurnool district of Andhra Pradesh. Their colour is white, black or grey. Their average weight varies from 25 to 30 kg. Their ears are of medium size and the tail is thick. The wool is mixed with hair. The wool is rough. Annual wool production is 0.4 to 0.9 kg and medullation percentage varies from 40 to 50% (Shahi, 1941).

2. ***Coimbatore:*** It is also known as Kurumbai. It is found in Coimbatore and Selam districts of Tamil Nadu and weigh 20 to 25 kg. Their face is white, black or black spotted. Rams may bear horns, but generally they are polled. It is good for mutton production. A sheep may produce 0.7 to 0.9 kg inferior wool annually. The staple length varies from 5 to 8 cm and has 55 to 60% medullation.

3. ***Deccani:*** It is found in the districts of Kolhapur, Nasik, Pune, Sangli and Satara of Maharashtra, Kurnool, Malgouda, Nizamabad and Bidar of Karnataka. Rams may or may not have horns sometimes ewes also have small horns. On an average they weigh 26 to 30 kg. Annual

wool production per sheep is 0.7 kg. Wool is of inferior quality and is used for making blankets.

*4. **Hasan:*** It is native of Chikmangloore and Hasan districts of Karnataka. They are small sturdier, strong with bright eyes, medium sized ears and thin tail. They are usually white but may have brown or black spots on their bodies. Rams are horned. The sheep on an average weigh 20 to 25 kg. The wool is white, rough and inferior. The annual wool production per sheep varies from 0.4 to 0.7 kg.

*5. **Kilakarsal:*** Also known as Kilakresal, Karuvi and Ramanad. They are predominantly found in Madurai, Ramanathpuram, Ramanad and Thanjavoore districts of Tamil Nadu. They are brown in colour but may have black spots on head and belly, Rams and ewes weigh 25 to 35 and 18 to 25 kg, respectively. Their ears are long but tail is short. The sheep are migratory (Ganesakale and Rathnasabapathy, 1973).

*6. **Mandya:*** It is also called Banure and is found in the districts of Banglore, Kolar and Mandya of Karnataka. Their average body weight varies from 21 to 25 kg. Face is brown; ears are long, leaf like. They are polled and kept for mutton and milk production. They are hairy.

*7. **Machheri:*** It is also called Melavadi. It is found in Salem and Coimbatore districts of Tamil Nadu. The animal have light brown or tan colour, light brown with spots on head, light brown with sides of body white, light brown with white spots of different parts of the body and complete white hair goat in 62, 18, 12.7 and 1.0%, respectively. Both the sexes are polled, they have well set body, legs are short and bony and udder is small in size. (Richard Jagatheesan *et al.,* 2003a). Ears are of medium size and the tail is short. Rams and ewes weigh 30 to 35 kg and 20 to 25 kg, respectively. The mean age at first lambing in use is 23.66± 0.09 months (Richard Jagatheesan *et al.,* 2003b). They are hairy (Acharya, 1982).

*8. **Madras Red:*** It is found in Madras and Chingalpet districts of Tamil Nadu. They are brown in colour. Rams and ewes weigh 32 to 35 kg and 20 to 25, respectively. Rams are polled.

*9. **Nellore:*** Found in Guntur, Nellore and Nalgonda districts of Andhra Pradesh. They weigh 29 to 34 kg, ears are long, tail thin and small and their body is hairy (Chakravarty and Haq, 1946).

*10. **Nilgiri:*** It is found in Nilgiri hills of Tamil Nadu. It originated in nineteenth century because of crossing of native sheep with Tasmanian Merino, South Down and Cheviot rams. They weigh 21 to 26 kg. Rams have small horns. A sheep produces 1.0 to 1.6 kg wool annually; whose fiber diameter is 25 to 30μ. The medullation percentage is very low (10 to 12 per cent).

*11. **Tenguri:*** Also know as Benguri and are found in Tingsagar,

Gangradi and Sathnore talukas of Raipur districts of Karnataka. They weigh 20 to 28 kg. They are dark brown but may have white or black spots. Rams are horned.

*12. **Trichuri Black:*** It is found in Paramboore and Arivaloore tehsils of Trichuri district and weigh 15 to 20 kg. They are black in colour and only rams are horned. Their ears and tail are small. The hair are rough.

*13. **Vemburi:*** It is found in Tirunavelley district of Tamil Nadu and weigh 25 to 32 kg. They are white with brown spots. Their ears are of medium size and tail is small. Rams have horns. They have small hair on their body.

*14. **Ramnad White:*** This breed is found in Ramand district and adjoining areas of Trunaloalo district of Tamil Nadu. They are white to colour but some have brown or black markings over the body. They are medium in size. Males have twisted horns but females are polled.

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3.
Housing

The various livestock species were living in wild state in jungles and grasslands before the process of their domestication. Domestication was human intervention with the aim to make livestock useful for the mankind by providing food, clothing, work, etc. Although the livestock breeds of arid regions are well adapted against the desert vagaries, their production potential is undeniably influenced by the harsh environmental conditions of the region. Extremes in the climate conditions can have enormous effects on the productivity of farm animals (Burke, 1998). Numerous studies indicate that the provision of shelter improves livestock performance through moderation of some of these effects. The main aim of the shelter is to provide comfort and a sense of well being to animals so that they can produce to their maximum genetic potential. However, in most parts of the Indian arid zone, shelter is not generally provided to the small ruminants whereas, thatched roof animals shelter is common for large ruminants.

Of all livestock, sheep are best fitted by nature to withstand cold weather. They have their own natural protection from cold. During cold weather, sheep prefer to remain out of doors, except during severe storms, if they are protected from strong winds. Moreover, sheep are usually associated with the system where, grazing is the major source of feed throughout the year. Consequently, for a portion of the year, little or no housing is necessary. Thus the shelter for sheep need not be expensive or particularly warm. During lambing season in winter, warm quarters should be provided, as the lambs are susceptible to chilling during the first few days of their lives. Hence, housing of sheep is considered as a less important feature than other livestock species. However, the housing system depends upon the breed, age, physiological status and climatic conditions for better production performances as well as to avoid predation during night.

The natural climate is not continuously optimum for livestock production throughout the year. Since man began to domesticate the animals, he has progressively restricted their freedom of selecting the best environment suitable for them during different adverse environment

conditions, which affect their development, response and growth. Therefore, the provision of suitable shelter to the sheep during the adverse environmental factors will buffer the extremes of these climatic factors and reduce the peak stress on them.

The following major points should be considered before constructing shed for the animals:

1. Topography: The building should be situated at a higher elevation than the surroundings to offer a good slope for rainfall and easy, economic drainage of the waste products, manure, urine, etc.

2. Soil type: Clay soil which considerably swells during rainy season may not be suitable for construction. Soil composed of gravel and sand is best suited for foundation.

3. Exposure to sun and protection from wind: Shed should be constructed to obtain maximum sunlight. The long axis should always be in north-south direction. For protection from strong winds fodder trees may be planted at least 10 feet apart from the sheds.

4. Accessability: The sheds should be connected to good roads.

5. Water supply: Fresh, clean and soft water should be ensured.

6. Durability and attractiveness: Sheds should be constructed with durable materials and may be designed in a proper manner i.e. round shape, L-shape or T-shape to give a scenic view.

7. Surroundings: Area infested with wild animals, poachers and industries may not be selected.

8. Labour: Farm should be at an approachable distance from the locality to ensure in time availability of labours.

9. Marketing: The market should be at an easy, approachable distance and the consumers should be in a position to accept the products at a comparatively reasonable price.

10. Electricity: The site may be at a reasonable distance for electrification.

11. Fodder production: There should be sufficient area surrounding the shed for fodder cultivation and its preservation as hay and silage.

12. Scope for future extension: Sufficient area may be available round the shed for future expansion.

13. Limited scope for spread of diseases: The site should be at a place where grazing of local animals is generally avoided.

Types of sheds

(a) **Open shed:** In this system there is no other special construction except for roof and fencing. This is good for healthy and adult stock throughout the year. During severe winter and summer, artificial protection with grass or bamboo, may be provided on the sides.

(b) **Semi open shed:** In this one side of the shed is open.
(c) **Enclosed shed:** This type of shed is fully enclosed with controlled environment, light and ventilation.

Farm plan

It is necessary to provide in the yard for housing sheep different types of housing for sheep kept for wool and mutton production. The general plans may be as given in Fig 3.1. The number of units of each type to be provided in the yard would depend on the number of animals to be looked after. The area of each unit shall depend upon the minimum floor space specified for each animal and the number of animals to be kept in each unit. The minimum floor space for each type of animal shall be as given in Table 3.1 below.

Table 3.1 Minimum floor space required per animal.

Type of animals	Floor space per animal (Sq. Meters)
Ewe	1.0
Ram	3.3
Lamb	0.4

Location

The housing for sheep shall be located on a dry, elevated and well-drained place, not exposed to strong hot or cold winds. A place where, there is a longer period of shade in the day is to be preferred.

Units

A yard meant for keeping sheep for wool and mutton production may have the following units:

(a) Sheds,
(b) Shearing and store room and
(c) Shepherd's house.

Sheds

The following types of sheds are required for housing the animals viz. (a) Flock shed; (b) Ram shed; (c) Lamb shed; (d) Lambing and (e) Sick animal shed.

Flock shed: The flock shed shall be used for housing ewes kept for breeding purpose. The shed shall be 15 × 4 × 3 m high and accommodates not more than 60 ewes.

Ram shed: The ram shed shall be used for housing rams kept for breeding purpose. The shed shall be 4 × 2.5 × 3 m high and

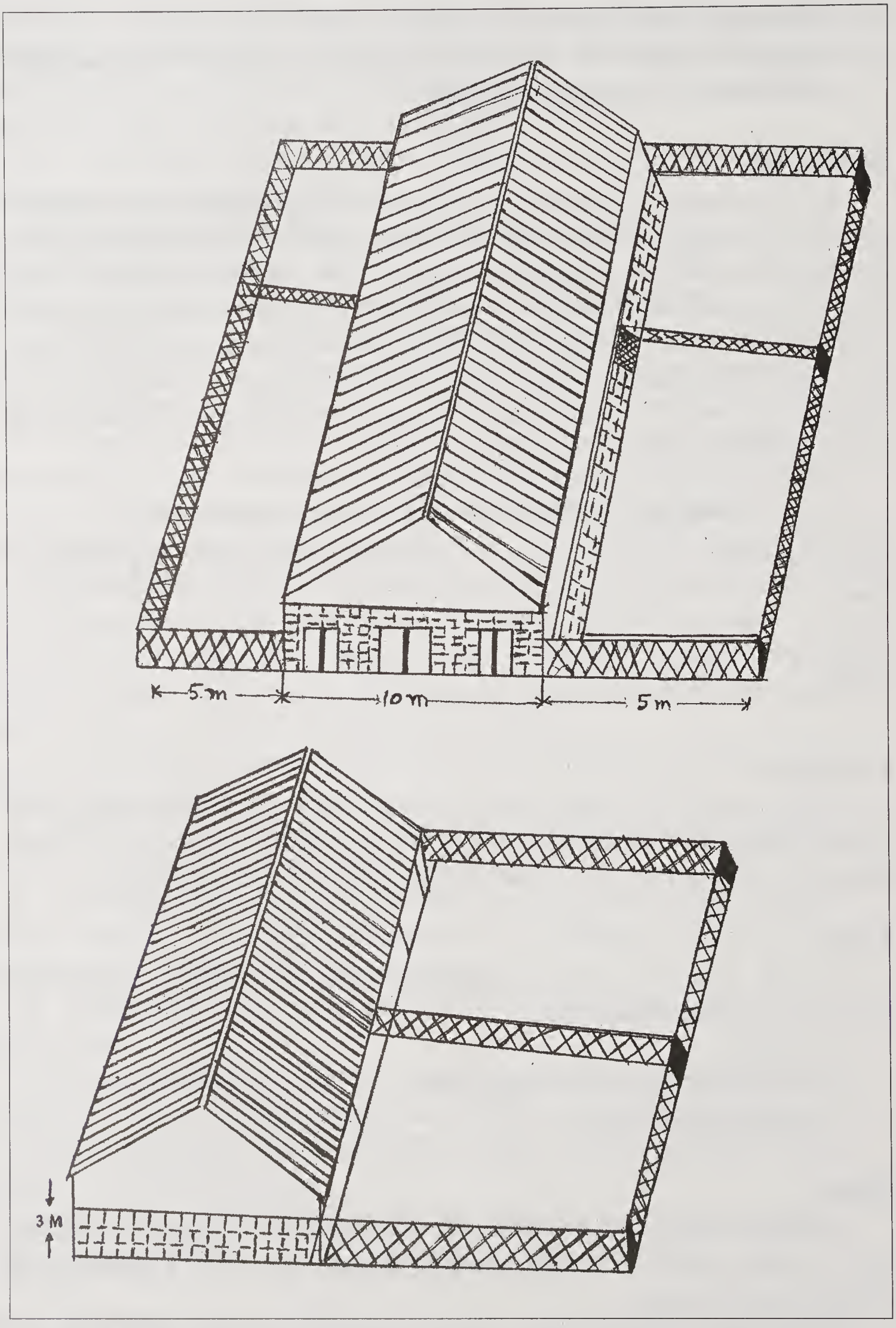

Fig 3.1. Farm Plan

accommodate not more than 3 animals. The shed shall be partitioned length wise to form four equal compartments as shown in Fig 3.1.

The partitions may be either of wooden planks or half cut ballies. The partitions shall be not more than one meter high from the floor.

Lamb shed: The shed be used for housing lambs until they attain maturity and are weaned and also those animals, which are weaned but have not attained maturity. The shed shall be 4.5 x 4 x 3 m high to accommodate not more than 50 animals. The shed shall be partitioned breadth wise dividing it into two compartments. The compartments having the dimensions 5 x 4 m shall be used to keep the unweaned animals and the other compartment having dimensions 2.5x 4.0 m shall be used for keeping the weaned but immature animals.

Lambing shed: The shed shall be used as maternity room for ewes. The shed shall be 1.5 x 1.2 x 3 m high. A manger for holding feed, hay and a bucket for keeping water is provided in the shed.

Sick shed: There shall be a sick shed for segregating sick and disabled animals. The shed be 3 x 2 x 3m high. There shall be a door, one meter wide and two meter high and one of the lower half of the door may be made of wooden planks and window 0.7 m broad and 1.2 m high with a wire net covering.

Shearing and store room

The shearing and storeroom may consist of two compartments with a dividing wall. One room may be exclusively meant for storing wool and shearing equipment and the other for keeping feed and medicines. The room may be 6 x 2.5 x 3m high. There shall be a door one meter wide and two meter high in the front side of the room. The door leaf may be made of wooden battens. It may also have two windows one on each side of the long sides of the room. Each window may be 0.7 m wide and 1.2 m high. The window may be covered with wire netting.

Shepherd's house

The shepherd's house meant for the caretaker shall be located at a convenient place in the yard. The house may be 6 x 4 x 3 m high. There shall be a door one meter wide and two meter high. The door leaf may be of wooden planks. There may be four windows one of these facing the passage of the yard and the other three facing outside. Each window may be 0.7 m broad and 1.2 m high and covered with wire netting.

Constructional details of units

Floor: The flooring may be either of *moorum* or of strong wooden battens and where the rainfall is quiet heavy, the latter type of flooring

may be preferred. In the case of wooden batten flooring the width of each plank shall vary from 75 to 100 mm and the thickness between 25 mm and 40 mm. The sides of the planks shall be well rounded and the clearance between two planks shall range between 10 mm and 15 mm to facilitate the disposal of dung and urine. The wooden batten flooring shall be constructed at a height of at least one meter above the ground level. In this case a suitable ramp or steps of wooden planks shall be provided. In the case of *moorum* flooring, a plinth wall between 150 mm and 300 mm high shall be provided, for the shearing and store room of and shepherds house the flooring may be of *moorum* or brick in cement mortar and the floor should be leveled properly.

Walls: The walls may be of bricks in lime mortar up to two thirds of their height from the common burnt clay building bricks. The upper one third part of the walls may be of chain link netting of galvanized steel barbed wire. The chain link netting may be supported by angle irons of suitable section and brick masonry columns placed alternatively at 1.5 m centre to centre. In the case of lamb shed the upper one third part may be of wire netting supported by angle irons. The walls on the three sides of the shearing and store room may be of brick in cement mortar. The front wall may be of brick in cement mortar up to one half the height from the ground level and the upper one half portion may be of wooden battens or wire netting. Aak (*Calotropis procera*), Bordi (*Zizyphus nummularia*) and Vilayati Babul (*Prosopis juliflora*) twigs are used to prepare sidewalls of the house.

Roof: Most of the materials for the construction of thatch roof, consisted basically of branches, twigs of Khimp (*Leptadenia pyrotechnia*) and Shinio (*Crotalaria burhia*) or Bui (*Aerva pseudotomentosa*). The roof may be made up of corrugated steel sheets or asbestos cement sheets and where the rainfall is not heavy, it may be of thatch.

Gate: Each shed may be provided with one or more gates on the long or broad sides of the sheds. Depending upon the dimensions of the shed the dimension of each gate may be 0.8 m broad and one meter high, the gate leaf and frame may be made of wooden battens.

Manger: The manger may be either of cement concrete or of wood with two compartments for providing food and hay. A separate hayrack may also be provided by fixing at level or slightly before the heads of the animals. With the half of clamp the manger may be raised within the height ranging between 450 and 600 mm from the ground. The water trough may be of cement concrete and or palls or buckets and may be fixed or hung from a hook fixed to the walls. The manger may also be of portable type. The number of mangers and water troughs in each shed may vary according to the number of animals.

Dipping tank: To protect the animals from infection, due to ectoparasites, the dipping tank may be made either of galvanized steel sheets or constructed of stone or brick in cement mortar. If a galvanized steel tank is used, it shall be well bedded down and the soil tight against it to prevent the sides of the bath from bulging when it is filled. If the base of the soil is unstable the tank may be bedded in cement concrete. The dipping tank may be at one side of the yard.

Footbath: A footbath made of galvanized steel sheet or brick in cement mortar shall be provided at the entrance to the yard to protect the animals from foot rot disease. These baths may be embedded in the soil suitably.

Shelter for the farm stock

Construct the shed large enough to provide 1.0 to 1.2 square meter of floor space per ewe. Make the door ways wide to prevent crowding and injury to pregnant ewes. Provide doors so that the building can be closed during lambing season and periods of severe storm. Slotted flooring is preferred which should be 1 meter above the ground level. The walls are made of brick in lime mortar upto 1.0-1.25 m height. The upper 0.5-0.7 m may be chain link netting of galvanised steel or barbed wire. The height of the shed at the centre should be 2.7 m and on the sides 1.5 m. Thatched roofing should be provided to prevent against severe heat and cold.

For lambing pens, construct panels about 1.2 m in length and fasten them in the building, providing about 1.5 square meter of floor space for the ewe and lamb. The panels can be hinged together in pairs.

Allow approximately 0.1 square meter of window space for each 2.0-3.0 square meter of floor space so that the interior will be reasonably lighted. An earthen floor is satisfactory if dry and kept well bedded. Gable type of building with sufficient space overhead for storage of bedding materials, hay and grain. This adds to the cost of the structure, but less labour is required in carrying to the stock.

Shelter for the range flock

For range flocks, shelters are primarily needed at lambing time. Central lambing quarters are provided. Moveable lambing equipment is used on some ranches. For most or all of the year, moving sheep to winter ranges, where the temperature is more moderate and where there is some natural shelter from intense winds provides the typical range flock. As a protection for sheep in open range, provide 1.5 meter high thorny wall and gate of 2.0 meter height to protect against wolves, predators etc.

Materials for shed construction

These are straw, asbestos, galvanised iron sheets, angle iron, tubular frame, cement, lime, sand and bricks.

Farm equipments

These are spring balance, clincher, ear tags, tag printing die set, hoof cutter, shearing scissors, measuring tape, feed and water troughs, hand trolley, axe, sickle, wooden scraper, buckets, torch, tattooing forceps, hay racks etc.

Measures to Overcome the Environmental Stress

The shade reduces the ambient temperature in closed houses and increases evaporation from their body surface and respiratory tract. The most effective shade is that provided by trees, as trees provide protection from sunlight along with cooling as moisture evaporates from the leaves. However, in the arid zones, trees may sometimes not be available for livestock shade. Hay or straw shades are the most effective artificial shade material. Providing shade during intense sunshine to sheep and goat reduces the heat load of these animals (Abdel *et al.,* 1998) and reduces the adverse effect of heat stress. Sheep having access to shade showed better growth rates, feed conversion efficiency and improved fertility in comparison to control (Moose and Rose, 1964, Davis *et al.*, 1994). The physiological response viz. respiration rate and heart rate were lower in sheep provided shade and nutritionally restricted or fed *ad lib* in comparison to those which were exposed in sun (Hooda and Naqvi, 1990).

Managemental practices

The success of farming system lies in observing certain routine practices, which help, in proper upkeep of the livestock and their records. The valuable information thus collected can be utilised for the improvement in the system and for better production from the animals. The following are certain managemental practices being routinely undertaken on a sheep farm.

Cleaning and disinfection of the shed

In slotted flooring, the dung and urine are accumulated below, which may be cleaned once in a week, the rest of the flooring should be cleaned daily.

Lime or bleaching powder may be sprinkled in the shed once in a week. The walls, floors and roofs may be disinfected with flame gun once in a fortnight. The walls may be white washed with limewater to

which 5% phenol is added. Sodium hydroxide @ 4% may be used as spray for disinfection. The frequency and type of disinfection can be decided according to necessity.

Ideal shed under village conditions

The methods of housing the sheep differ according to climatic conditions. In tropical regions open sheds or semi open sheds are suitable for providing shelter to sheep in order to protect them from severe rains, heat and predators. For open sheds and semi open sheds, no special construction is required. Only fencing and roofing is essential. The materials required for construction of such sheds should be chosen depending upon the availability of articles locally at cheaper rate. Iron angles, wire, asbestos sheets, thatch, galvanised iron sheets, poles, bamboo, bushes, wooden planks, slates, etc. are the materials required for fencing and roofing and one can select the articles for construction of such sheds according to his economic situation. The space required varies from breed to breed and individual to individual as such dimension of the shed also varies.

Open sheds and semi open sheds are good for healthy adult livestock throughout the year. However, during severe winter and summer artificial protection made up of grass and bamboo may be provided on the sides. The difference between open shed and semi open shed is slight. The semi open shed is open only on one side.

In temperate regions, viz, Jammu and Kashmir, Himachal Pradesh and Uttaranchal majority of notable sheep breeders are nomads. They carry their sheep flocks to lower hills during winter season and again migrate their livestock to alpine pastures during summer months. They remain always on migration and do not construct any shed for their sheep. However, some sheep breeders do not take their sheep flocks to winter abode and are kept at their native place even during the season when heavy snowfall is ensuing. Under such conditions permanent sheep sheds are required to be constructed for protecting the animals from biting chills and to minimise the deaths from pneumonia. For construction of permanent sheep sheds, it is desired that it should be cheap and hygienic and warm. The materials needed are stones or bricks, mud plastering, wire mesh netting, wooden beams and plants, bhojpatra, bushes, earth, etc. and if financial position permits, iron sheets or slates can be used for better roofing. During very severe cold, the doors, windows are kept closed and covered with curtains made up of gunny bags. The animals remain entirely on stall feeding till summer months set in.

The design of a modern shed at Sheep Breeding Farm Tal (Himachal Pradesh) or Central Sheep Breeding Farm, Hisar, is given here. In this

type of shed, special attention has been given to the flooring system. The cement and stone flooring stain the wool and is unhealthy to sheep. Similarly, the *'Katcha'* flooring is also not suitable. Therefore, to avoid all this, wooden batten flooring has been used in these ideal sheds.

In this type of flooring, the floor is constructed about 2 meters above the ground level with the wooden battens 4-6 cm wide fitted at a distance of 1.0 cm from which urine and droppings can fall down easily. These sheds have been constructed in the shape of big halls of 50 m x 30 m size, sub-divided into 8 to 10 compartments of required size for different age groups of animals and different purposes. The walls of 2 to 2.5 m height from this wooden flooring with sufficient number of windows and ventilators have been provided. The roof is of slanting type and with the beam height from floor is 3.0 to 3.5 m. Entrance is provided from both the ends. The compartments are interlinked in such a manner that minimum manual handling of the animals is needed in performing various operations in the shed. The space for shearing and treatment is also provided along with feed storage facilities. The urine and droppings slip from the batten flooring which keeps the flooring clean and animals don't soil themselves. The droppings, etc. are collected from the ground floor at regular intervals and converted into a high quality manure. In this way minimum labour is involved in addition to the healthy atmosphere for the animals and production of good quality wool. A shed of 50 m x 30 m is sufficient for keeping 1000 to 1200 sheep of different ages and sizes and to perform different operations.

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Establishment and Culling

The different physical characters of sheep should be known to us to start a breeding farm. Judging of stock is the foremost step to start with the breeding farm as appearance alone is not always a reliable guide to its breeding values. A wrong judgment may vitiate the objective. Before starting a sheep farm, the purpose of starting sheep rearing should be clear in the mind of the sheep farmer. Normally sheep farming is done for mutton, wool or pelt production. Different breeds of sheep are reared for different purposes. It is very essential to have primary information about these breeds. Sheep farmer should be aware about the demand of the particular product in the market, e.g. wool, mutton or pelt. It is better to start sheep farming with the breed predominant in that area.

After knowing these points, ewes and rams should be selected carefully for the flock. Ewes should be 2-4 toothed, active, good size and wider pouch girth. None of the teats should be blind. The wool should be uniform on the body. Moving hand on the back can do this. The sheep that have lambed for the first time should be selected. They should be free from diseases.

The maxim that "the ram is half of the flock," because the quality of the lamb born depends upon the ram. Ram should have good quality wool on its body. It should be healthy, sturdy and high quality breed ability. Its legs should be strong, back wide and age between 2-3 years. If selected for wool, it should have uniform cover of wool all over its body. The wool fiber should be thin and fine. If it is selected for mutton, its body should be uniformly meaty, legs small and straight. Following points are to be kept in mind while selecting a breeding ram:

(a) **Look for twinning history:** In order to achieve a high lambing rate, one should search a ram with known history of twinning.

(b) **Select heavier rams:** The selection of a ram should be based on body weight basis because body weight is correlated with fleece weight and density. Normally the rams in private flocks are selected at the weaning stage as the weight at weaning is correlated with mature body weight.

(c) **Select healthy rams:** Selected breeding ram should be vigorous, free from diseases, internal and external parasites.

(d) **Buy early:** Do not wait until the last minute to find a ram. It is a desirable practice to get new rams accustomed to new environmental and feed conditions so they will be ready for the breeding season. A good rule is to purchase rams a month or two before turning them, with the ewes.

(e) **Obtain rams according to the quality of ewes:** Always keep in mind the poorer points of your ewe flock and buy rams that way to be able to correct these faults

(f) **Seek advice of others:** Experienced breeders or other similar individuals can assist materially in helping the inexperienced to obtain good rams.

(g) **Selection based on production records:** The surest way of selecting rams for breeding purpose is by a production test. Production testing includes (i) the type and finish at weaning time, (ii) prolificacy, (iii) weight gains upto weaning and (iv) the weight and quality of fleece. A ram whose offspring has shown up well in production test is known as proven sire.

Selecting for fine wool

In addition to above general points, more emphasis is required on following points while selecting for wool.

1. **Quality of wool:** The number of crimps, medulation percentage and staple length and fibre diameter determines the quality of wool. Wool, finer than 24.4 m is considered as "A" grade, 30.0 to 34.4 m as "B" grade 37.0 to 40.0 m as "C" grade and above 40 m as "D" grade. The finer wool does not have any medullation. Fibre length more than 5.0 cm is suitable for worsted system.
2. **Quantity of wool:** The quantity of wool is determined by the fibre density, fibre diameter and staple length. If the number of fibres per sq. cm. is more, the animal will produce more wool.
3. **Condition of wool:** The condition of wool is measured by the presence of foreign matter and yolk. The purity of wool is judged by the absence of black fibres, kemp and hair. While selecting sheep for fine wool, absence of hair and kemp should be ensured. The colour of the wool should be white.
4. **Confirmation of the animals:** None of the native breeds is of fine wool type. Some crosses such as Avivastra, Bharat Merino, Hissardale, Nilgiri and Chokla and Nali synthetics have superior quality wool.

   The animal should have wide, strong contribution with wool on

belly, legs and face. The wool should be fine long and white colour. They should not have black patches on body. Wool yield and staple length of the wool should be more.

Selecting for mutton

Deep, wide, blocky body, thick fleshy, strong constitution and quality characterize these animals. The mutton of these animals should be tender and juicy. The skin should be pink in colour, which indicates good health. The animals should have strong head, back and loin. The size of the animal should be proper as per its age, sex and breed.

Selecting for pelt

The rams should have strong and bold head and neck. The ewes should have fineness of features with maternal instinct. The grade of pelt of lamb should be given more weight.

Precautions in using the selected ram

Points that are to be kept in mind before using the selected ram for breeding purpose are:

(i) **Feeding of rams:** Well balanced ration should be fed to breeding rams at least a month earlier to start of breeding and should be continued till breeding operation is over.

(ii) **Number of ewes per ram:** Under range conditions, three rams per 100 ewes is a desirable ratio. Yearling rams can handle 25 to 40 ewes. However, a mature strong ram of 2-5 years old may handle upto 75 ewes, although 35 to 50 is the most desirable number of ewes for breeding season under farm conditions.

(iii) **Shearing of rams:** Shear the breeding rams allover if they are to be used early. Atleast shear legs, neck, brisket, belly and scrotum. Ram will be more active and it is easier for them to cover an ewe if they are shorn.

(iv) **Care of the feet:** Rams and ewes should have their feet well trimmed so that they can walk naturally; and

(v) **Cryptorchidism:** Ram with one testicle retained within the body cavity/abdomen should not be used for breeding purpose, as there is tendency to occur in succeeding generations, although it will not appear in all cases.

Age of sheep

Normal age of sheep varies from 10-15 years. Its production capacity starts decreasing after 6 years of age. It is very essential to have knowledge about their age for purchasing or selling. The age of sheep

can be judged from the number of rings on the horns in horned breeds, but it is not possible in most of our sheep. To judge the age of the sheep, condition of the teeth is helpful. The number and condition of teeth indicate the age of a sheep. Like other mammals, sheep have two sets of teeth, viz. the temporary set called the milk teeth and permanent set.

The lamb has small, narrow teeth that are known as milk teeth. At twelve to fourteen months of age, the two center incisors are replaced by two large, broad permanent teeth. Each succeeding year, an additional pair of permanent teeth appears, one on either side of the first pair, until at four years of age when there is a full mouth. A mature sheep has 32 teeth, of which 24 are molars and 8 are incisors. All incisors are in the lower jaw. The two central incisor teeth are called pincers; the adjoining ones intermediate, the third are, second intermediates, and the outer ones, corners (Table 4.1).

Time at which these teeth come, varies with different breeds, e.g. in Nellore sheep 1st, 2nd, 3rd and 4th pairs of incisors erupt on an average at 1 year 3 months, 1 year 8 months, 2 years 2 months and 2 years and 8 months, whereas, the corresponding ages for Mandya breed are 1 year 5 months, 1 year 11 months, 2 years 9 months and 3 years and 4 months.

Table 4.1 Relationship between age and dentition in sheep

Age	Number of Permanent incisors	Sheep commonly called
6 months	None (8 milk teeth)	Lamb
1 -1.5 years	2	2 teeth
1.5 - 2 years	4	4 teeth
2.5 - 3 years	6	6 teeth
3 - 4	8	Full mouth

In this way all the incisors erupt by 4 years of age. This method is simply a method of estimation, because the eruption of incisors depends upon breed, condition of pasture, etc. Fourth pair of molars erupt at 3-5 month of age and fifth and sixth pairs of molars develop by 1½-2 years of age. The positioning of teeth at different ages are as follows:

Formula for Temporary teeth: $\frac{0}{4}\ \frac{0}{0}\ \frac{3}{3}\ \frac{0}{0}$

Formula for Permanent teeth: $\frac{0}{4}\ \frac{0}{0}\ \frac{3}{3}\ \frac{3}{3}$

It is difficult to tell the age up to which the teeth remain useful. They start falling at the age of 5 to 6 years. In some cases they may not fall even upto an age of 8 to 9 years. With the advancing age the gums start shrinking and the roots of the teeth are exposed. If the one or more than one incisors fall in a sheep, such sheep are called "broken mouth". The sheep whose all the incisors have fallen is called a "gummer". The sheep with broken mouth or gummer cannot cut; with the passage of time they loose condition.

Implements needed for sheep farm

Following articles are needed at an organised farm:

1. Feeding troughs of 3.6 × 0.25 × 0.25 meter size can be used which can be made up of wood, iron, cement, concrete and bricks.
2. Water troughs of 3.0 × 0.25 × 0.25 meter can be used for watering sheep.
3. Aluminium tags and clinchers.
4. Tatooing machine with letters and number set with tattooing ink.
5. Docking knife.
6. Rubber bands and elastrator for docking.
7. Burdizo castrator.
8. Dial type 5 kg Salter balance for weighing lambs.
9. Dial type 20 and 100 kg, hanging type Salter balance.
10. Vaccination syringes and needles
11. Iron dipping tank.
12. Foot bath made up of aluminium
13. Scissors for shearing wool
14. Hoof pairing knife
15. Milk feeding bottles
16. Gas stove
17. A.I. kit and
18. Drenching cup/ gun.

Sheep Farm Calendar

The success of farming system lies in observing certain routine practices that help in proper upkeep of livestock and their records. The valuable information thus collected can be utilized for the improvement in the system and better production from the animals. There are certain operations as shown in Fig 4.1 being routinely undertaken in a farm as a package of practices for progressive sheep farming. According to season, the operations followed at farm can be divided into five as given below.

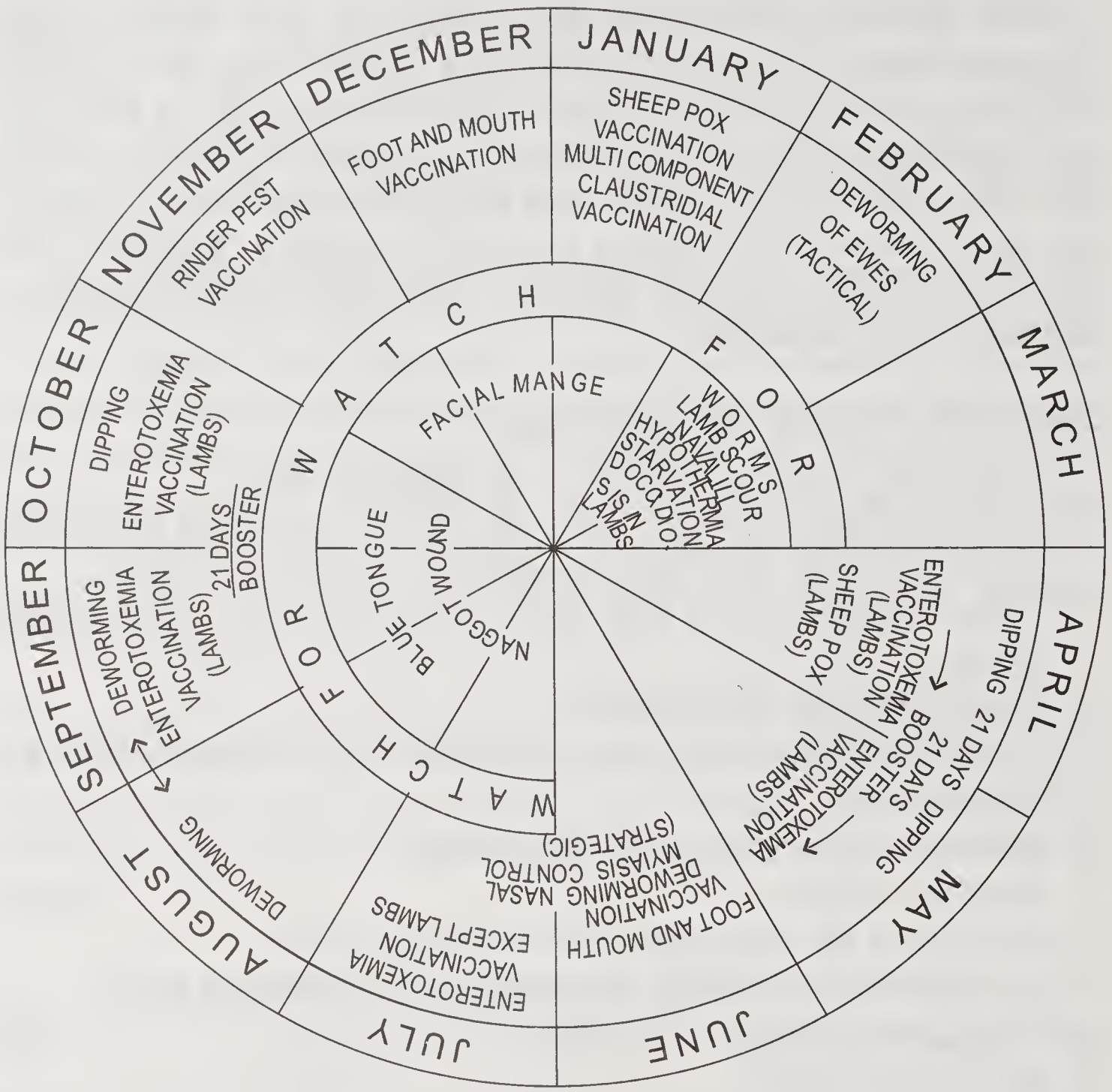

Fig. 4.1 Sheep health calender followed in CSWRI, Avikanagar

1) Spring (February to March)

This part of the year is neither very hot nor very cold. The grasses start sprouting at the end of the winter season. In addition to these stubble grazing is also available in gram-harvested fields. The sheep start coming in heat. Sporadic cases of enterotoxaemia are also noted. The sheep should be vaccinated against this disease during this period. The sheep are dipped in H.C.H, Gerathion or Smithion solution, 10-15 days after shearing, if there are no hearing wounds on the body. This is done to kill ticks, lice etc.

2) Summer (April to June)

The climate becomes hot and grasses start drying, but sheep survive on stubble grazing in wheat harvested fields. They get Acacia pods, 'Khejari loong' and 'pala' leaves during this period. They also come in heat during this period. These leaves and pods are excellent source, of

nutrition for pregnant sheep. They should be given supplemental ration during scarcity periods.

3) Rainy season (July to August)

With first showers, grass starts sprouting. The sheep start gaining weight, due to pregnancy and getting good grazing. The lambing starts by the end of the rainy season. The sheep should be drenched against internal parasites. They should be protected against foot rot.

4) Autumn (September to October)

Shearing operation starts during this period. Culling is also done at this time. Some of the left sheep also become pregnant. Lambing of sheep continues. Tail docking and castration are also done during this period. Sheep get sufficient fodder in Maize, Jowar and Bajra harvested fields.

5) Winter (November to January)

The grass starts drying and scarcity period starts. Sheep gone on migration on mountains start returning to plains. The lambs should be protected from cold. The sheep in arid region go on migration.

Culling

In addition to improved management and health practices, culling of sheep is also very essential to keep the flock in good condition. It is better to keep a few sheep giving more and good quality wool than a large number giving small amount of inferior wool. Best time for culling is at shearing because at this time wool quality can be judged and body can be examined thoroughly (Buch and Jayaraman, 1953).

All those lambs that do not represent the breed, have black spots on the body, bent legs and suffering from contagious diseases should be culled.

Rams who produce inferior quality semen and wool and their age is more than five years should be culled.

Sheep, which are black in colour and have black spots on the body, the wool is yellow inferior and small in quantity and weighs less than the average of the flock can be culled. They should not have mastitis and giving small amount of milk. They should not have broken mouth and represent the breed. The ewes whose shoulders are not broad and have over or under shot jaws should not be retained in the flock.

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5.
Migration

Transportation by its nature is an unfamiliar and threatening event in the life of domestic animals. During transport, animals are exposed to various environmental factors such as heat, cold, humidity, noise, motion, over crowding etc. However, during long journeys the space provided should ideally allow stability, normal posture and postural adjustments, without causing an increased risk of injury and physiological 'stress'. Confinement on the moving truck is the most stressful aspect of the transport process (Rajesh Kumar *et al.*, 2002).

The means of transporting sheep are not well developed. Normally, the sheep may be transported by road, rail, ship or airplane. Very little recorded information is available regarding the problems encountered during their transportation (Matharu, 1962, 1963a,b; Kale, 1966). Only trained hands should be selected for escorting sheep. Sick and lame animals should not be transported. Care should be taken to feed and water them before transporting. During transit, sheep should be given water twice a day and fed 1.0 to 1.5 kg of good quality hay or given pala or gram bhoosa. They should be fed at each resting point. In each truck or wagon there should be two attendants to lift the sheep, whenever they fall. If sheep are to be transported by road, the journey should be started before dawn. If the journey is long and the day is hot, better undertake journey during night. Approximate space per sheep needed in a truck or Rail wagon is given in Table 5.1.

Table 5.1 Space needed while transporting sheep by rail or by road.

S.No.	Body weight of sheep	Space per sheep in Sq. meter.	
		In a Truck	In a Rail Wagon
1.	25 kg wool	0.20	0.21
2.	30 kg wool	0.22	0.23
3.	25 kg shorn recently	0.19	0.20
4.	30 kg shorn recently	0.20	0.21
5.	40 kg wooled	0.24	0.25
6.	Pregnant use	0.28	0.32

Small lambs should be separated from their mothers and provided safe place in a corner to save them from being trampled. It is better to keep them on upper deck.

Trucks and wagons should be thoroughly scrubbed, cleaned, disinfected and properly bedded. The CA type wagons with wooden floor should be preferred for transporting sheep. A broad gauge wagon of this type can be used for transporting 75 sheep and truck having a floor area of 4.8 × 1.2 m; can carry about 50 sheep (Table 5.1). It is better to bring the sheep to loading. This will give them a chance to rest and empty their bowls to ease abdominal pressure.

Migration of sheep also takes place in search of fodder. Most of the sheep farmers do not have land to graze their sheep. The time of migration coincides with the start of drying of the grass after rainy season. In famine years 80-90% sheep move out on migration to other provinces. Some sheep go on migration for a short period and others remain on migration for a longer period. The route of migration is given in Table 5.2. For the convenience it can be divided into two parts depending on the area from where, the animals are migrating:

(I) In plains: Sheep migrate in plains due to failure of rains in winter season or due to being sheep in large numbers in that area. 1.5 million sheep migrate in Rajasthan every year. Out of these 0.6 million remain on migration throughout the year. Normally migration starts after Diwali. If there are good winter rains, the migration may start after the harvesting of fields in March/ April.

Flocks from Rajasthan migrate to Delhi, Gujarat, Maharashtra, Madhya Pradesh and Uttar Pradesh and flocks from Kutchh region of Gujarat migrate to Jalore and Sirohi districts of Rajasthan (Table 5.2). Eight to ten flocks of a village join to form a bigger flock. A man moves ahead of flock to know about the position of fodder and water in the next village. A flock covers 600-1000 km during one migration. A donkey and a camel cart moves with the flocks, which is used for carrying newly born lambs and their luggage. Tying prepuce of the ram with a woollen thread regulates breeding in the migratory flocks. Sheep return with the onset of rains. At that time they are 2-3 month pregnant.

(II) In mountains: Sheep move out on migration in mountains with the onset of summer season. While grazing, they climb upto 3000- 5000 m height. There are 400-500 sheep in each such flock. Six to eight week old lambs move with the sheep during migration. Sheep farmers cook their food themselves. They carry a piece of tarpaulin to make tent for resting at night. Sheep and lambs are given common salt once or twice a week. Sheep are not watered upto 2-3 days. Sheep farmers believe that

Table 5.2 Routes of migration of sheep in plains

Route	Period of Migration	Months of Shearing	Places of Shearing	Wool Quality
Nagda Region:				
a) Jalore, Sirohi, Ratlam, Nagda	November to July	Mid December to Mid February	Nagda, Agra	Medium to inferior
b) Jodhpur, Pali, Falna, Neemach, Ratlam	November to July	Mid December to Mid February	Nagda, Agra	Medium to inferior
c) Ajmer Bundi, Jhalawar, Ujjain, Indore	November to July	November	Kota, Jhalawar	Medium to inferior
Gujarat Region:				
Jaisalmer, Barmer, Jodhpur, Palanpur	November to June	February to March	Diga , Palanpur	Medium to inferior
Eastern U.P.				
a) Jaisalmer, Barmer, Jodhpur, Ajmer, Dudu, Jaipur, Bharatpur, Agra	Mid November to December	February to April	Jaipur, Dausa, Bharatpur	Usually un-washed.
b) Ajmer, Niwai, Chaksu, Dholpur	Mid November to December	February to April	Niwai, Dholpur	Usually un-washed.
c) Jalore, Pali, Jodhpur, Ajmer, Jaipur, Chaksu, Dholpur, Lalsot, Gangapur, Gwalior, Itawa, Mainpuri.	November to July	January to May	Jaipur, Chaksu, Lalsot Etawa, Mainpuri	Medium to inferior
d) Ajmer, Jaipur, Dausa, Bharatpur, Agra, Hathrus	November to July	January to May	Jaipur, Chaksu, Lalsot Etawa Mainpuri	Medium to inferior
Kuchh Region :				
a) Junagarh, Dhar, Indore, Ujain, Jhansi	May to June	July to August	Kota, Jhalawar	Medium to inferior
b) Dhanduka, Baroda, Indore, Abu Road	May to June	July to August	Shivganj, Sirohi	Medium to inferior
c) Ajmer, Radhapur, Sanchor, Barmer	May to June	July to August	Balotra, Barmer	Medium to inferior

by doing so they eat more. Rams are normally kept with the ewes. The flocks return to plains with the onset of rainy season.

Transhuman Pastoralists

One of the complex but none the less interesting socio-ecological phenomenon in arid areas is the existence of transhuman pastoralism. This may be in the form of nomadic and semi-nomadic life styles of pastoral and non-pastoral communities associated with livestock rearing. In Banni area of Kutch district, Gujarat, Sindhi Muslim livestock breeders are the most predominant transhumance Pastoralists. This phenomenon is extensively prevalent in Rajasthan desert. Raikas, Ghanchies, Gujjars, Sindhi Muslims, Rajputs, Jats, Bishnois, etc. or the movement of the herdsmen, with village cattle, sheep and goats to the summer pastures away from the centers of settlements and permanent cultivation, are following this practice since generations.

The full impact of these transhumance communities on the overall economy has not been studied so far to any great extent. Studies consider their relationship with the local people as generally symbiotic and very rarely competitive. Now there is a friction being developed among the settlers and the nomadic people. Another factor to be studied is effect of these seasonal movements on the grazing lands and management aspects of these through which be the numerous migratory routes. Again there is a very limited information available on the pasture areas such as their extent, types, fodder potential, incidence of grazing and the problems connected with their management. On the other hand no detailed study has been made of the nomadic grazeirs themselves, the migratory routes they follow, the difficulties they encounter and their human and social problems associated with their peculiar life styles.

Transhuman Pastoralism

The pastoralists of arid areas specifically the desert areas of Rajasthan State feature a considerable range of subsistence activities that incorporate a degree of mobility in their overall strategies of adaptation. Hence pastoral groups of different kinds (Sheep and goat farmers, cattle farmers, buffalo farmers, etc.) and of different caste/clan in large numbers are transhumant populations. An attempt has been made to highlight certain aspects of social organization and economy as a preliminary indicator of the depth to which the feature of migration viz. pastoralism has been incorporated into the region's rural economy. This will be supplemented with the development after identifying factors and perceptions for the future.

The phenomenon of Transhumance has been defined chiefly in the context of mobility for survival. It is a form of adaptation – the response to a specific ecological and socio-economic situation employing in varying degree of dependence the subsistence techniques of both

agriculture and pastoralism and characterized by differential ranges of mobility. These systems of adaptation are known as Transhumant. The distinctive feature of the transhumant adaptation is the emergence of a seasonal pattern of mobility co-ordinating the two subsistence activities.

Indian Grassland and Fodder Research Institute, Jhansi has highlighted eco-sociology and range resources, People's involvement for range improvement. Studies in Gujarat State pertain to Banni Pastoralists (Bharara, 1987; 1988;) dealing with the socio-economic aspects of pastoralists and recommendations for development.

Socio-economic characteristics of the pastoralists

Desert pastoral communities are characterized by high growth rate of population and massive illiteracy; traditionalism and socio-religious beliefs and social organization and institutional arrangements based on caste, family and form of settlement. Fragmented land holdings with static farming and traditional pattern of livestock rearing viz; animal husbandry are the chief subsistence, sources of livelihood. Over exploitation of natural resources is in vogue to meet with the increasing, demands of food, fodder, fuel and water. This lead to deterioration of land, water and vegetation resources causing low productivity and low income associated with livestock migration and pastoralism. One of the complex but none the less interesting features of human settlement in Western Rajasthan is the existence of transhuman pastoralism. This may be in the form of nomadic and semi-nomadic life styles of Raikas, Ghanchies, Gujjars, Sindhi Muslims, Rajputs, Jats, Bishnios, etc. or the movement of the herdsmen, with village cattle sheep and goats to the summer pastures away from the centers of settlements and permanent cultivation (Table 5.3).

Socio-economic problems

Earlier the relationships of animals and environment, balance between pastoral nomadism and natural environment, relationship between pastoralists and sedentary peoples –cultivators, livestock traders, etc. were largely complementary. With the socio-cultural and technological transformation of the society, the functional relationship has undergone considerable changes. Symbiotic relationship between the settled non-pastoralists and the pastoralist nomadic population has broken down. Settled population no longer welcomes the nomadic pastoralists. While on the move livestock of the pastoralists are associated with the destructive activities pertaining to soil conservation. The routes followed by the pastoralists have narrowed down due to extension of cultivation. Increase in livestock population, taking up

Table 5.3 Socio-economic characteristics of desert pastoralists

Characteristics	Composition of Livestock household (%)
Predominant communities:	
a) Agro-livestock raisers (Rajput, Jat, Bishnoi Seervi, Mali, Rajpurohit etc.)	40
b) Livestock raisers (Sindhi Muslims, Raika, Gujjar, Ghanchi)	25
c) (Lohar, Suthar, Meghwal, Craftman, etc.)	35
Religion :	
Hindus	82
Muslim	18
Nature of family:	
Nuclear	42
Joint	58
Mean size of family:	7.5
Literacy level	
Illiterate	72
R&W	13
Literate	15
Form of settlement:	
a. Compact	55
b. Scattered	7
c. Compact-cum-scattered	38
Average size of land holding (ha)	8
Average number of livestock/family	43
Livestock population	
Sheep & goats	70
Cattle	20
Others	10

livestock rearing as the less risk oriented occupation by the non-livestock rearing communities and overcrowded grazing lands have exaggerated the problems of the pastoralists and put their future in doledrum. All these factors in a rapidly changing world have affected their existence.

Further increasing livestock pressure from 9.90 million in 1951 to 23.32 millions in 1983 and 28.17 million in 1997 and so on predominance of sheep and goats together constituting more than three-fourths of total livestock, overcrowded permanent pastures and other grazing lands and migratory practices have deteriorated the grazing lands. Deforestation and cutting of vegetation by the people for fuel and sale during droughts, for charcoal making and earning livelihood have

all encouraged deterioration of grasslands causing fodder crisis for the pastoralists.

Conflicts between cattle and sheep raisers with respect to common property resources utilization

Because of scarcity of resources conflicts or disputes regarding utilization of grazing lands comprising of goachers, orans, wastelands and water resources, etc. often occur between the cattle raisers and sheep raisers. If sheep raisers graze their stock in the goachers lands, the cattle raisers object to it and sometimes-serious conflicts occur taking the shape of quarrels, assaults and even murder. Conflicts also take place while using grazing lands including harvested fields, fallow lands, etc. during livestock migration.

Nature and extent of transhumance

Migration of more than one month was prevalent in the pastoral, rainfed and irrigated tracts of arid zone. Study has revealed that 124 out of 309 households had migrated during the drought year of 1984. More than two-fifths (40%) of the households had migrated along with their livestock whereas about three-fifth (60%) of the households had not sent their livestock to graze outside the village grazing grounds (Table 5.4).

Table 5.4 Tract wise migration of livestock (% Households)

Tracts	Yes		No		Total	
	Number	%	Number	%	Number	%
Pastoral	60	48	66	52	124	100
Rain fed	35	39	55	61	90	100
Irrigated	29	31	66	69	95	100
All Tracts	124	40	185	60	308	100

Pastoral nomadism is a livelihood form that these communities have ecologically adjusted at a particular technological level to the utilization of marginal resources. In rainfed dry farming areas migration during summer due to paucity of water and grazing is very common among the Jat and Raika flock owners. Sheep and goats migrate towards Jaipur/Haryana side while cattle migrate towards Kota side. On an average a migrating herd constituted 150 livestock being managed on an average by 2.5 persons during migration. In the irrigated tract, only livestock migration was common among the large flock and cattle owners during the drought years. Of the various migratory communities, pastoralists need a special mention of their way of life.

Summer and rainy season type of livestock migration for a short period of less than one month and of long period of more than one month was chiefly prevalent in the pastoral, rainfed and irrigated tracts. Routes were determined on the basis of grass/fodder, water and availability of agricultural labour. Decision of migration routes to be followed was chiefly taken collectively (48% of the households) in all the tracts. There were 31 different routes of livestock migration to be followed by the livestock raisers of all the tracts. Of the various reasons of sending livestock for long distances were shortage of fodder followed by drought/ famine occurrences fear of death, water and fodder difficulty and shortage of food grains were the most predominant reasons in all the tracts.

Social parameters of transhumant communities

In dry areas livestock migration – a phenomenon of transhumance was chiefly prevalent among agro-livestock rearing communities. Scarcity of water, fodder, grazing lands and recurring droughts and famines were reported to be the chief causes of migration. Out of the past twenty-two years (1958-80) , migration took place for fifteen years and more than ten per cent of the total effective surveyed households migrated (Table 5.5).

Table 5.5 Social parameters of transhumance

Parameters	Details
Castes migrated	Agro-livestock raisers: Raika, Gujjar, Jat, Seervi.
	Others – Meghwal, Sargara, Nayak
Year of migration	Drought years: 1958, 1961, 1963, 1964, 1967, 1968, 1969, 1971, 1974, 1977, 1978, and 1979 Flood year 1980).
Causes of migration	Shortage of water, fodder and grazing lands; frequent droughts and famines: habitual nomadic life.
Migratory person's relationship with head of household	Self, son, relative, village people, caste people, hired workers, etc.
Migratory unit:	
Herd size	Animals 12800.
Mean number of persons and animals/herd	Persons/herd, 13 animals/herd, 457.
Month of start	Usually October or November.
Month of return	May-June of next year
Distance covered	Approximately 400 to 1200 kms.

Source: Bharara, 2003

It was found that during the last five droughts or famine years, twenty-eight herds constituting 12,800 heads of livestock alongwith forty-three persons migrated. On an average, a migratory herd had 457 heads of livestock and fifteen persons. Among the people accompanying livestock migration, household head, non-relative, village people and hired workers used to go with the livestock. The routes followed by their forefathers, were still being followed though they expressed increase in difficulties. The end points being touched by these migratory households were Malwa (Madhya Pradesh) Rajasthan (Uttar Pradesh) border viz; Kota, Bharatpur, Agra, Hathras, Aligarh etc.

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6.

Sheep and Lamb Management

The good care and management of sheep flock is necessary to explore the production potential of animal for wool, milk and mutton. This is to be done with in the framework of economic limitations and resources available with the farmer. Normally sheep come in heat throughout the year, but they come in heat in larger numbers after the harvesting of *Rabi* crops (Kaushish, 1980). Soviet Merino and Rambouillet come in heat in larger numbers in autumn than in spring season. If these are bred in the beginning of the breeding season, the conception rate is poorer than when bred in the middle or at the end of breeding season. The twining percentage is lower during first lambing (Kaushish and Sahni, 1977a). For the convenience, management of sheep can be divided into three parts:

Dry ewes

No extra care is required for these animals. Regular grazing for 8 to 10 hour on a good pasture is sufficient to maintain their weight. The sheep continue to come in heat every 17-18 days unless they become pregnant. Many shepherds forget about the ewes after they are mated and start looking forward to her delivering a lamb after 5 months. The care of pregnant ewe is important as the lamb develops during this period and this development in turn determines, the rate of growth of the lamb after birth. A well looked after and properly maintained ewe during pregnancy will have a good flow of milk, when the lamb is born and will be able to develop and maintain good health later in life. On the other hand if the pregnant ewe is not cared for, the lamb born may be weak or develop poorly and die or there may be loss due to abortion and the ewe herself may be so weakened that she may be inclined to disown her lamb and may require much more attention at lambing time.

Pregnant ewes

The control over the nutrition of the pregnant ewes is essential for economic reasons. The nutrition of the pregnant ewes must be

concerned not only with the definition of nutrient requirements but also with an assessment of the effects on production levels of feeding which are lower than their full requirements. It is convenient to divide the period of gestation as follows: -

i. The first 3½ months (early pregnancy)
ii. The last 1½ months (late pregnancy)

The first 3½ months: Ewes in good body condition at mating shed more ova and have lower rate of embryo mortality than ewes in poor condition. The effects of current nutrition on embryonic mortality are less. Embryo survival can be adversely affected by severe under nutrition, even of very brief duration. It is a good practice to avoid under nutrition during breeding season and also in the subsequent 2-3 weeks. During the second and third months of gestation, the various tissues and organs of the foetus are undergoing rapid development, although the absolute weight of the foetus is under rapid development, the absolute weight of the foetus is still relatively low. By the end of third month, the fetus has about 300 g or approximately 14% of its birth weight. Placenta attains about 95% its final weight of about 250 g per fetus by the 90th day of gestation.

The literature does not present a clear picture of what constitute an optimum level of nutrition. In attempting to these apparently anomalous results, it is necessary to take into account a number of factors including the age and condition, ewe and the level of late pregnancy nutrition. It is clear that the under nutrition during mid pregnancy can reduce the weight of the foetus and of "the placental material at 90 days. Compensatory growth of cotyledonary tissue and particularly of that part associated with the foetus is known to occur during late pregnancy, but this will of course require a. relatively high level of nutrition at that later stage. One must take into account the age and condition of the ewe at mating in making any recommend regarding nutrition during mid pregnancy. An acceptable weight loss during 2-3 months of pregnancy is about 5% of mating weight.

The last 1½ months: The growth of lamb starts from the later part of pregnancy. By this time the placenta is almost fully developed and major foetal tissue and organs are formed and all that remains is an increase in size and weight. In addition to the nutrients needed for foetal growth and development plus those required to support the other products of conception, nutrients are needed for the satisfactory development of mammary tissue and of course to meet the maintenance requirements of the sheep herself. Care should be taken that pregnant ewes do not lose weight during this period. It is very essential to give supplemental

feeding to sheep. If good quality fodder is fed during this period, the lambs born will be heavier at birth and sheep will be able to produce sufficient quantity of milk (Sehgal and Kaushish, 1989). Pregnancy allowance of 300 to 400 g concentrate and 500 g of good quality hay to the indigenous and 500 g concentrate and 500 g good quality hay to exotic and crossbred ewes be given from this period till the lamb is weaned (Table 6.4).

Lactating ewes

During the earlier weeks of life, the growth of the lamb is largely determined by the amount of milk it obtains from its mother. The methods of estimating yield have been reviewed by Boyazoglu (1963). Although the effects of nutrition on lactation in the ewes are well established in principle, the diversity of conditions under which the experimentation has been carried out makes it difficult to describe relationship between feed inputs, milk production and weight changes which are of general validity.

Energy requirements for ewes during lactation have been published in UK by MAFF and Boaz *et al.,* (1973) and in the USA by NRC (1975). There are wide variations in the estimates of both the energy requirements for maintenance in sheep and the efficiency of conversion of metabolizable energy to milk energy. The efficiency of utilization of body tissue for the production of milk energy has not been measured in ewes and a value estimated in the dairy cow (Mae *et al.,* 1971) has to be used.

The response of the lactating ewes to metabolizable energy intake has not been well defined, as most experiments have not had treatments spread over adequate range of nutrition for the response curve to be established. In some experiments (Owen and Ingleton, 1963; Gardner and Hogue, 1964), the differences in milk yield were approximately proportional to the levels of intake but in others (Bamicoat *et al.,* 1949) the responses were less than the differences in intake. In the first 4-6 weeks of lactation, reductions in live weight usually occur and these losses may be large. Maintenance or gains in weight in early lactation are usually associated with low milk yields (Guyer and Dyer, 1954). Robinson *et al.* (1974) and Calderton cartes *et al.* (1977) have demonstrated rapid responses to dietary protein concentration in ewes in negative energy balance in early lactation.

Management

Pregnant ewes should not be subjected to fright. They should not be crowded together, nor allowed to jump over hedges or ditches. They

should not be driven through narrow passages, nor taken to long marches during the hotter part of the day. They should be provided shade adjacent to midday watering points during hot summer days.

Preparation for lambing

The pregnant ewes should be shorn 4 weeks before the onset of lambing. If the ewes are not shorn, atleast crutching should be done on hindquarters, around the tail, vulva and udder to avoid soilage at the time of parturition. Lambing of ewes should be done in two ways. (1) Open air or range lambing - in which the ewes have their lambs on pastures in warm climate. The shepherd should pay more attention in protecting the lamb and ewe from predators and assist the ewe in difficult lambing. (2) Shed lambing or pen lambing - in this the shepherd provides clean and neat pen for lambing of ewes. The shepherd should remove droppings every day in the morning. The pen should be in a position to protect the lamb and ewe from predators. Sufficient light may also be provided in the lambing pen.

If the size of the flock is large, the pregnant ewes may be separated and grazed separately so that the individual ewe receives due attention. Two teeth ewes need to be watched more closely as they sometime run away after giving birth to the lamb. The shepherd should remain closer to the flock but move slowly without disturbing the ewes. The incidence of the difficult births is higher among young ewes. The shepherd should assist the ewe at the time of lambing.

If the breed involved is a poor milker, it may be ensured that sufficient number of milking goats are available in the flock when the lambing is to commence. When the lamb is born it is a general practice in the villages to give 250g of sweet oil and handful of molasses to each ewe. Most of the farmers believe that the feeding of the oil and the mollasses induces the production of sufficient quantity of milk in addition to helping them in recouping their health. The oil and molasses, both provide the high energy needed by the lactating ewes to cater to the needs of their offspring.

In young ewes and malnutritioned ewes, the placenta may not be thrown fully due to weakness, at that time it is better to give pitutrine to the ewe to help in letting down of milk and throwing the placental remnants to avoid metritis and poor milking. Sometimes the young ewes disown their own lambs. To rectify the disowning of the lambs, use different techniques such as (1) tying the ewe several times a day along with lamb and (2) tying a dog out side the pen (3) putting the ewe milk on the body of her lamb and (4) placing the skin of the dead lamb over the orphan lamb.

Lactation

When the lamb is born, first thing that the shepherd does is to ensure that within half an hour or forty five minutes, it begins to suckle and if he finds that the lamb is unable to suckle, he should assist it in doing so. Each lamb should receive the attention of shepherd. In a number of cases, it may happen that the milk supply of the ewe is insufficient. Ewes those are otherwise normal and free from fever or infection may be used to feed their milk to such lambs. Succulent fodders such as silage or root crops are excellent for this purpose. In the meantime the lamb will have to be fed either by foster mother (she Goat), cow milk or milk taken from other ewes. The lambs should be allowed to remain with the ewes to get milk they may produce, as frequent nursing encourages milk production. Hand feeding should be used as a supplement to the ewe's milk. When ewes fail entirely to come to their milk, the lambs will have to be hand fed entirely unless they can be placed on another ewe.

Treating plugged teats

Ewes' teats often become plugged either by thickened colostrum or from skin growing over the teat opening due to an injury. Soon after the lamb is born a little milk should be drawn from each teat. This will remove any thickened milk and assure the lamb of being able to get its food. If skin has grown over the teat opening, sterilised teat siphon may be used to open the teat canal.

Symptoms of parturition

Sheep tries to separate herself from the flock. If shed is in the shade it tries to search for a peaceful comer. She scratches the ground with her fore hooves, gets up and sits down frequently, lies down on right side and stretches out its legs outward. She grinds her teeth frequently. Respiration rate increases (Kaushish and Arora, 1974a). Native sheep mostly lamb between 3-6 AM and 3-6 PM (Kaushish *et al.*, 1973).

Normally pasture grasses are deficient in phosphorus and protein, in addition to these deficiency of vitamin A is also observed. To compensate for the deficiency of these, they should be given barley, gram, guar, sorghum or cakes like groundnut, mustered, cotton seed cakes or leaves of Khejari (*Prosopis cinreria*), Ardu (*Ailenthus excelsa*), Ginga and Acacia pods. To compensate for protein and energy deficiency, they can be given urea-molasses-mineral bricks (Table 6.1). If they are fed dry fodder with these, it becomes better than green fodder and concentrate mixture.

Table 6.1 Components of a lick.

Name of material	Quantity (kg)
Water	2.0
Molasses	10.0
Urea	1.5
Mineral mixture	1.0
Common salt	0.5

Dissolve urea in water then add molasses; mineral mixture and common salt. Add 10-15 litres of water to this mixture and spray it on 100 kg chaffed fodder and feed to adult sheep. It can be fed to pregnant sheep also; lambs below 3 months of age should not be given this ration (Sehgal and Kaushish, 1989).

Table 6.2 Methods of feeding

Type of animal	April to June	July to August
1 Rams		
a) Used for breeding	i. Urea molasses mixed fodder 500 g	Concentrate mixture 300g
	ii. Concentrate mixture 200 g	
b) Not used for breeding	i. Above treated fodder 750g	-
2. Ewes		
a) Non pregnant and pregnant upto 3½ months	i. Above treated mixture 1000 g	-
b) In last 1½ month of pregnancy	i. Above treated mixture 750 g	Concentrate mixture 300g
c) Up to 1-month lactation.	i. Above treated mixture 700 g	Concentrate mixture 450g
d) In 2nd and 3rd month of lactation	i. Above treated mixture 500 g	Concentrate mixture 300 g
	ii. Concentrate mixture 200 g	
3. Lambs		
a) 0-1 months	Green fodder only	Green leguminous
b) 1-2 months	Concentrate Free choice	Concentrate free choice
c) 2-3 months	Concentrate 50-250 g	Concentrate free choice
d) 3-6 months	Concentrate 350 g	Concentrate 350 g

Lambs

Efforts should be made to take maximum care during early stages of life, when growth takes place. Normally native sheep gives birth to one lamb at a time, but crossbred sheep give birth to one or two lambs at a time. For effective lamb management and for reducing the lamb losses, care of the ewe should started from the time of conception till the lamb is weaned. The most critical period in the life of the lamb is during first 48 hours of life. To make profits from sheep husbandry, it is essential that more lambs are produced and they survive (Jayaraman and Buch, 1953). For this, it is essential that they get sufficient quantity of milk at appropriate time. The management of lambs can be divided into two parts for the sake of convenience:

Up to 1 month

The face, eyes and rest of the body are covered with membranes at the time of birth, normally, ewe herself cleans the lamb, but if she does not do it, they should be helped. If the mother of a lamb dies or does not suckle its lamb, such lamb should be put to other ewe which has sufficient milk or her lamb has died. If the ewe does not adopt such orphan lamb, the placenta of such ewe should be rubbed on the body of the lamb. The skin of the dead lamb can be tied on such lamb. If she still does not adopt such lamb, then her fore legs should be tied and a dog may be tied near by. She may adopt lamb because of fear.

If she still does not adopt lamb, then it will have to be fed artificially. Lamb should be given warm milk mixed with cod liver oil. It should be protected from hot and cold winds. It should be given milk 6 times a day up to first fortnight, 4 times a day in second fortnight and twice a day up to 3 months. Water should be provided to lamb in the shed. The floor of the shed should be dry and covered with bedding so that it does not start licking soil. It should be provided soft leguminous succulent fodder (Table 6.2). It should be given concentrate mixture and be taken to pasture after it is two weeks of age. The composition of concentrate for lambs is given in Table 6.3. The quantity of concentrate to be fed to lambs at different ages is given in Table 6.4.

Table 6.3 Composition of concentrate mixture for lambs and adult sheep

Contents	Lambs	Sheep
Maize/barley	50%	58%
Groundnut cake	30%	10%
Wheat bran	16%	28%
Trace elements	02%	07%
Common salt	02%	02%

Table 6.4 Quantity of concentrate mixture for native and crossbred lambs

Age	Native lambs (g/day)	Crossbred lambs (g/day)
Up to 1 month	30-60	50-100
1-2 months	50-100	100-200
2-3 months	100-150	200-300
3-6 months	150-250	300-400
6-9 months	200-250	300-350
9-12 months	200	300

Identification of lambs

Common methods of identification of lambs are:

Ear marks: Earmarks, made with either a sharp knife or a regular ear notcher, can provide identification for sheep. Such marks are permanent and easily recognized, but unattractive.

Metal ear tags: It is a common method in our country. Sheep are provided with a metal ear tag in each ear, bearing breed and number. Metal ear tags are easily attached but easily lost. Also, they frequently rub or scratch the skin, thus making openings for screwworm infestation.

Ear or Thigh tattoo: This method of marking consists of piercing the skin with instruments equipped with needlepoints that form letters. Rubbing indelible ink into the freshly pierced area follows this operation. On dark skinned animals, tattoos are difficult to read, therefore, it is avoided.

Docking and castration

Since sheep were first domesticated, castration has been carried out to eliminate indiscriminate breeding and tail docking to reduce the damaging effects of fly strike. Both practices are still considered by sheep farmers, in many parts of the world, to make management easier and more productive, sufficient to outweigh the costs. Under the changing circumstances of sheep husbandry, management and marketing, however, new costs must be taken into consideration, including the perception of consumers of the suffering to animals. It has been made clear by independent organizations such as the Farm Animal Welfare Council in the UK that castration and tail docking of lambs are of public concern.

Justification for castration and tail docking

Most sheep farmers accept that castration and tail docking of sheep should be carried out only after careful consideration of the benefits and costs to the animals, their owners and to consumers. Others carry out the procedures as part of an established tradition and may not appreciate the need to justify them.

Costs and benefits of castration

In addition to preventing indiscriminate breeding, castration reduces unwanted sexual and aggressive behaviour and makes male lambs easier to handle and to keep penned.

It is claimed that castrated lambs show more weight gain and have a better eating quality than uncastrated lambs: the meat is more tender, easier to cook and has less smell (taint). However, the evidence for these claims is not accepted as conclusive by others who claim that uncastrated lambs grow faster, have more lean meat, are just as tender and are no more difficult to cook and that the meat does not smell any stronger than that from castrated lambs. Meat processors also claim some benefits of castration, the skin being easier to remove if there is a no scrotum and more subcutaneous fat.

The main costs of castration are to the lambs, which are affected by both the procedure and the loss of sexual potential. Several studies provide substantial experimental evidence that lambs experience considerable pain and / distress from the commonly used methods, (Molony *et al.,* 1993; Lester *et al.,* 1996; Thornton and Waterman, 1997) while there is little experimental evidence that they do not. The feelings of those who are obliged to carry out these procedures also need to be considered. The costs to the owner are in the form of time, instruments and any losses in productivity, such as increased prenatal mortality and disease susceptibility due to reduced intake of colostrums, immunological deficiency induced by the pain/distress and increased handling stress. Costs to the consumer include more expensive lamb when castration decreases productivity, and perceptions of animal suffering, for which they accept some responsibility.

Costs and benefits of tail docking

Fly strike is a major disease and welfare problem in many parts of the world and tail docking is accepted as the most effective and economical way of reducing its severity. If fly strike does not occur or can be easily avoided, e.g. by preventing faecal soiling, there appear to be a few other substantial reasons to tail dock. However, the appearance of lambs of some breeds with long tails is considered by some to detract from their value and failure to comply with such aesthetic considerations can have significant economic costs.

Control of Castration and Tail Docking

The 'three Rs' Used as the basis for control of scientific procedures on animals can be applied to castration and tail docking of lambs, use of the procedure should be reduced (fewer lambs should be treated),

replaced (alternatives should be found) and refined (better methods should be sought).

Reduction and replacement can be achieved if lambs from rapidly growing breeds/strains are slaughtered before sexual behaviour and fertility cause a management problem and before the quality of the meat is reduced. If the profit from individual lambs were high enough, the management costs of raising fast growing lambs and the alternative of separating ram and ewe lambs could be accepted, especially if this added marketing appeal as a welfare-friendly production system. The development of such systems may require control of lamb production and although this has been part of agriculture policy in Europe for many years, only recently has it been influenced by welfare considerations. High-cost production systems are undermined and rejected, however, if they are in direct competition with lower-cost systems with poorer welfare standards. Thus, the introduction of welfare considerations into the sheep industry is heavily dependent upon consumers valuing lamb highly and paying accordingly.

Refinement requires clear understanding and awareness of the welfare costs and of practical ways to minimize them, involving research to establish and upgrade best practice. This research can be carried out under experimental conditions and by sheep farmers in the field and has led to the adoption of different approaches to castration and tail docking in different parts of the world. In the UK, the rubber ring method has evolved as the method of choice for castration and tail docking of young lambs, but its use is restricted by law to lambs under 1 week old.

Several research groups have attempted to assess the pain/distress experienced as a result of castration and tail docking of lambs by measuring the effects of various methods on behaviour and physiology. There appears to be agreement that, without effective analgesia, lambs do experience considerable pain/distress from all the methods commonly used (Molony *et al.,* 1993; Lester *et al.,* 1996; Thornton and Waterman, 1997) and that less painful methods should be found. Economic pressures require that any such methods be quick, easy, effective and reliable.

Methods of castration and tail docking

Societies whose way of life depends on animals generally show them great respect, regret the need to carry out procedures such as castration or tail docking and show distaste for the process. There are also instances where societies appear to have ritualized these procedures to help them cope with the distress of the animals.

The method best for castration and for tail docking?

There is no simple answer to this, as the method that may be best for very young lambs is not necessarily optimal for older lambs and methods best in some countries may not be appropriate in others. After deciding that lambs must be castrated. It is also necessary to decide how important it is that they are made completely infertile and that none show sexual behaviour. This will assist in making a choice between surgical removal, induction of ischaemic testicular necrosis or some other approach. A brief description of the advantages and disadvantages of generally practiced methods is included. Details are given elsewhere.

Surgical castration and tail docking: The main advantages of this method are that it is certain and that pain can only arise from the remaining tissues. The disadvantages are those any surgical interference: pain, stress, inflammation, infection, hemorrhage and the time needed for healing, all of which can reduce productivity and most of which are minimized by established surgical skills. The disadvantages are considered to outweigh the advantages in some countries.

Bloodless castration: The main advantages are that, because the skin remains intact, there is much less chance of infection and it is quicker and considered by some to be easier to carry out, than the surgical methods. Crushing with a bloodless castrator should occlude the blood supply to the tests and destroys the innervation of tissues beyond the crush, causing atrophy of the testes and making the tissues insensitive. The disadvantages are that rupture of crushed blood vessels can lead to haematomas and failure to apply the instrument correctly may not subject the spermatic cord to the necessary destructive forces to ensure atrophy of the testicular tissue. The bloodless castrator produces a burst of intense pain as it is applied, which should be short lived but is followed by considerable pain from tissues damaged at the line of the crush. Bloodless castrators are not often used for tail docking, owing to operators' perceptions of the severity of this method and its unreliability if the unwanted tail is not cut off at the same time.

Ischaemic castration and tail docking with rubber rings: The advantages are that rubber rings are quicker and easier to use, as well as being more reliable than bloodless castrators. They can be used for both castration and tail docking and the Elastrator used to apply them is easy to use, cheap, robust, reliable and durable the disadvantages are that lambs experience acute pain for up to 2 hours, followed by chronic inflammation, sepsis and pain until the affected parts fall off and healing occurs. This can take more than 6 weeks for lambs with large scrotums (Fig 6.1 and 6.2).

All of these methods produce behavioural and physiological changes that have been interpreted as indicative of considerable acute pain

Fig. 6.1 Tail Docking in Lambs with rubber band

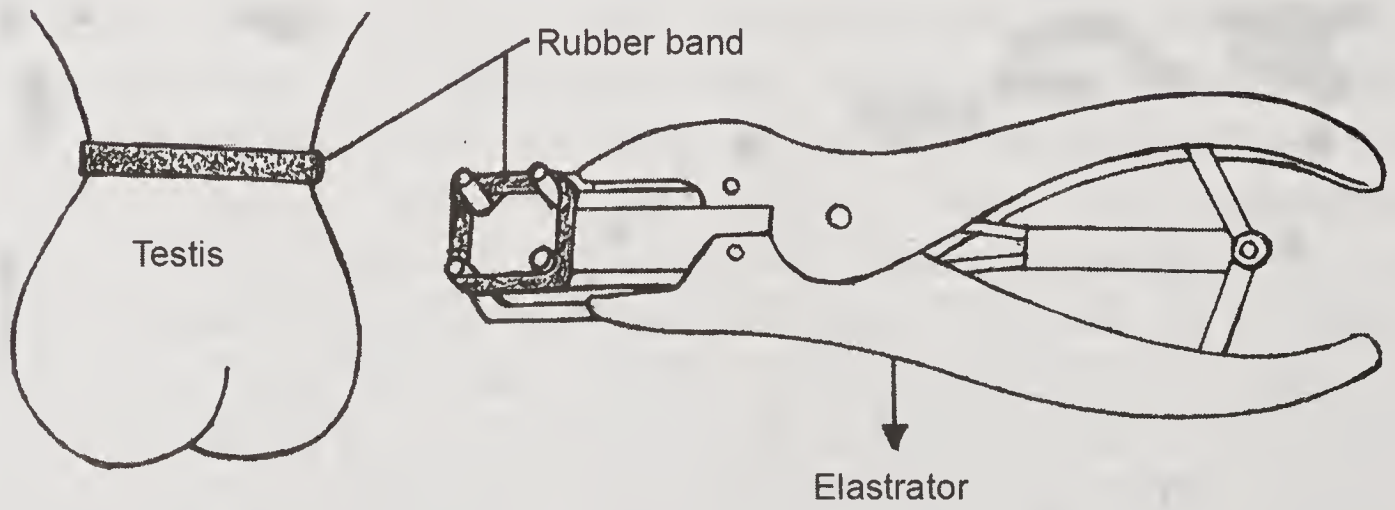

Fig. 6.2 Elastrator

(Molony *et al.,* 1993; Kent *et al.,* 1993 Lester *et al.,* 1991; 1995; 1996, Thornton and Waterman, 1997) and although there is debate as to which produces most acute pain, e.g. between the surgical and the rubber ring methods, it is agreed that they give rise to different kinds of pain, the intensity and duration of which require methods for reduction or alleviation to improve the welfare of the lambs.

The chief reasons for docking lambs are:

1. Docked lambs are cleaner.
2. Long tails interfere with breeding ewes.
3. Docked lambs and sheep presented a uniform and blocky appearance.

4. The dressed carcass has a more attractive appearance

Methods of docking or tailing lambs

1. In lambs under the age of three weeks the tail may be cut away by a firm stroke with a sharp knife. Some bleeding occurs but in young lambs it is seldom serious.
2. Tailing by means of docking iron (hot chisel or hot pincer) should be carried out on older lambs, say at the age of eight to ten weeks. The iron is heated sufficient to sear the flesh, thus preventing excessive bleeding and reducing risk of the tail stump.
3. The modern method that is bloodless, humane and avoids the risk of infection is placing a small, highly tensile rubber ring with the help of elastrator (Fig. 6.2) between the segments of the tail, causing atrophy and separation. It is preferred when lambs are seven to fourteen days old. The effect of docking on fat deposition and breeding performance has been studied by Qureshi (1968) and Qureshi and Shaw (1968).

Castration

Wether lambs produce more desirable carcass having a greater development in the regions of high priçed cuts. Wether lambs are quieter and fatten better than ram lambs. Ram lambs also annoy the ewe lambs of the flock. These are the chief reasons for castrating male lambs.

Methods of castration of lambs

1. When sharp instrument like knife is used, the hands, instruments and site of operation should be thoroughly disinfected with good disinfectant. After disinfection, with the help of sharp knife, remove lower third of scrotum, exposing the testicles that are then drawn out by a special forceps until the spermatic cords break. The method known as "drawing" can be safely used in case of lambs between age of three to six weeks.
2. For older lambs, it is advisable to use a clamp before severing the testes from the cord and to apply a hot iron to seal severed ends. This prevents serious bleeding. The method is usually employed in rams used in breeding flock, where late castration is unavoidable because male lambs must be given adequate time for development before the best are selected for breeding purpose.
3. The bloodless method involves the use of a special instrument known as the "Berdizo" which can exert great pressure on the spermatic cord through the walls of scrotum. There is no cutting or loss of blood and the tissues of the cords are so damaged by pressure

that the testes atrophy and disappear in the course of time. This method is more humane and avoids the risk of infection. But this procedure has a major disadvantage i.e. a small percentage of lambs may be imperfectly castrated if not operated carefully. Such lambs will show rather more masculine characters. Hence it is worthwhile to check up thoroughly a month after castration.

4. The elastrator method involves placing a small, highly tensile rubber ring around the neck of the scrotum as soon as the testes are present in the scrotum. The pressure of this ring causes atrophy of the spermatic cord and scrotum by cutting off blood supply.

Hoof pairing

Overgrown hoofs occure when sheep are housed, particularly those sheep flocks which live on clay and loamy soils, there is a tendency for the feet of such sheep to become soft and to develop an abnormal growth of hooves. The front part of hoof usually grows too long, while the wall tends to curve inwards over the sole. Mountain flocks living on stony soils may need little attention to their feet because normal wear permits normal growth.

Failure to deal with excessive hoof growth creates a grave risk of foot rot, the majority of such cases being of an infectious nature and likely to cause widespread infection in a flock. Trimming should cause no bleeding and confirm to the anatomy of the foot so that sheep can stand and walk normally. Feet bleed when the living tissue involved in the hoof growth tissue is cut and healing of this damaged tissue will distort the foot. Timely use of the pairing knife preserves a good shape and proper bearing surface to the hoof. This reduces the risk of foot rot to a minimum. Even if foot rot is not apparent, minute and detailed flock examination once a year is a part of good management (Adams and Mc Kinley, 1995).

Weaning

Lambs should be weaned when they are more than 3 months of age. If it is not done they continue to suckle up to 5-6 months of age. They can harm teats while doing so. Some sheep farmers apply dung to prevent them from suckling. This is unhygienic. This may cause mastitis also. It is better to graze them separately and keep them in a separate enclosure. At weaning they should be given sufficient amount of good quality fodder. In addition to grazing, they should be given concentrate mixture also. They should be given anthelmenthic drench immediately after weaning.

The weight of lambs increases by 11 kg if they are given 500 g of

concentrate mixture in addition to 8 h grazing; it increases by 7 kg if they are fed only cowpea hay. The lambs can be given pelleted feed available in the market. It has been observed that lambs eat 6% more of such concentrate mixture as compared to ordinary concentrate mixture and produce 23 per cent more meat.

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7.

Reproduction

The importance of the technique of artificial insemination is very well established for quickly improving productivity of native sheep. The factors which are considered favourable for adaptation of large scale artificial insemination in the country are non-seasonal nature of sexual activity in sheep, the lack of seasonality in semen quality of rams, plenty of cheap available labourers and sunshine for the location of cervix. Lack of organizational efforts comes in the way of implementation of artificial insemination programme. The fertility of the ram semen drops seriously when it is stored in refrigerator for a period beyond 6-24 hour. Current experience with chilled and frozen semen is not satisfactory and, therefore, call upon new methods/alternatives which could be effectively used to minimize the drawbacks in the scientific application of artificial insemination (A.I.) programme. However, the successful exploitation of A.I. depends upon gathering more knowledge in applied reproduction and management of sheep.

Any amount of research on storage of semen without fertility tests on large scale has little relevance to its application in sheep development programmes. Reasonable conception rates have been obtained with freshly collected and diluted semen but there is a need to conduct further researches on storage, packing, transportation and utilization of ram semen and also on the effect of storage temperature, site of insemination and number of live and normal spermatozoa on fertility.

It is necessary that researches on allied aspects of male and female reproduction be also carried out to evolve a sound basis of application of artificial insemination in sheep. Better conception rates could be expected from artificial insemination, when basic information on reproductive behaviour of male and female is available in case of native and exotic sheep in this country. The non seasonal character of sexual activity in tropical sheep, the availability of ample labour in this country together with the fact that all the ewes in a flock could be detected in heat within a span of 20-30 days, could make a reasonable case for adoption of artificial insemination in this species.

Semen Production

Studies on the age of puberty and maturity revealed that majority of indigenous and crossbred rams (50%) start showing sexual desire and start donating semen at an age of 8-9 months, when they attain 20-25 kg body weight. Good quality semen can be obtained at the age of 10-12 months. There was full establishment of spermatogenesis and presence of matured Leydig's cells in testis and seminiferous tubules for secretory activity in seminal vesicles. Fine wool exotic breeds (Rambouillet and Russian Merino) and higher crosses (75%) attained puberty at the age of 18 months with 35.0 kg body weight. Delayed puberty is observed in exotic and higher crosses (Tiwari and Sahni, 1982;Tiwari and Kalra, 1982). Because of variations in environmental temperature, rainfall and humidity, the seasonal changes in semen quality of exotic, indigenous and crosses have been reported by many workers (Ramamurthy, 1963; Singh and Roy, 1963; Misha and Sengupta, 1965; Sahni and Roy; 1967a,b; Kaushish and Sahni, 1977b; Dhillon *et al.,* 1979; Sinha *et al.,* 1979; Mittal, 1980; Saxena and Tripathi, 1987).

Good quality semen suitable for breeding purposes could be obtained from indigenous and halfbred rams though out the year (Sahni and Roy, 1972 c, d; Honomode and Tiwari, 1974; Tiwari, 1978; Mittal, 1984,1985). However, deterioration in semen quality was observed in exotic and higher crosses during summer months (Sahni and Roy, 1972a,b, c, d; Tiwari and Sahni, 1974b, 1975; Kaushish and Sahni, 1976, 1977b; Mittal, 1984) (Table 7.1). Provision of artificial cooling like under ground housing, electric fan and room coolers could not prevent seminal degenerations during these months in exotic breeds (Tiwari and Sahni, 1974a; Kaushish and Sahni, 1977a); (Table 7.2). Deterioration in semen quality in exotic rams due to season as extreme as summer, sterility are characterised by marked spermatogenic degenerations. The effect of high temperature coupled with increased daylight has been responsible for production of inferior quality semen in exotic rams (Singh and Roy, 1963; Misha and Sengupta, 1965; Sahni and Roy, 1972c; Tiwari and Sahni, 1975; Rai *et al.,* 1976; Sahni and Roy, 1967a).

Semen production in relation to frequency of semen collection revealed that semen collected upto four times daily, either continuously at an interval of 10-15 minutes or twice in quick succession during morning and evening hours for a period of 20 or 40 days did not bring any changes in semen quality of indigenous and half bred rams (Sharma *et al.,* 1969; Honmode and Tiwari 1974; Tiwari and Sahni, 1982). However, deterioration in semen quality with marked increase in number of refusals was observed in exotic rams when placed on

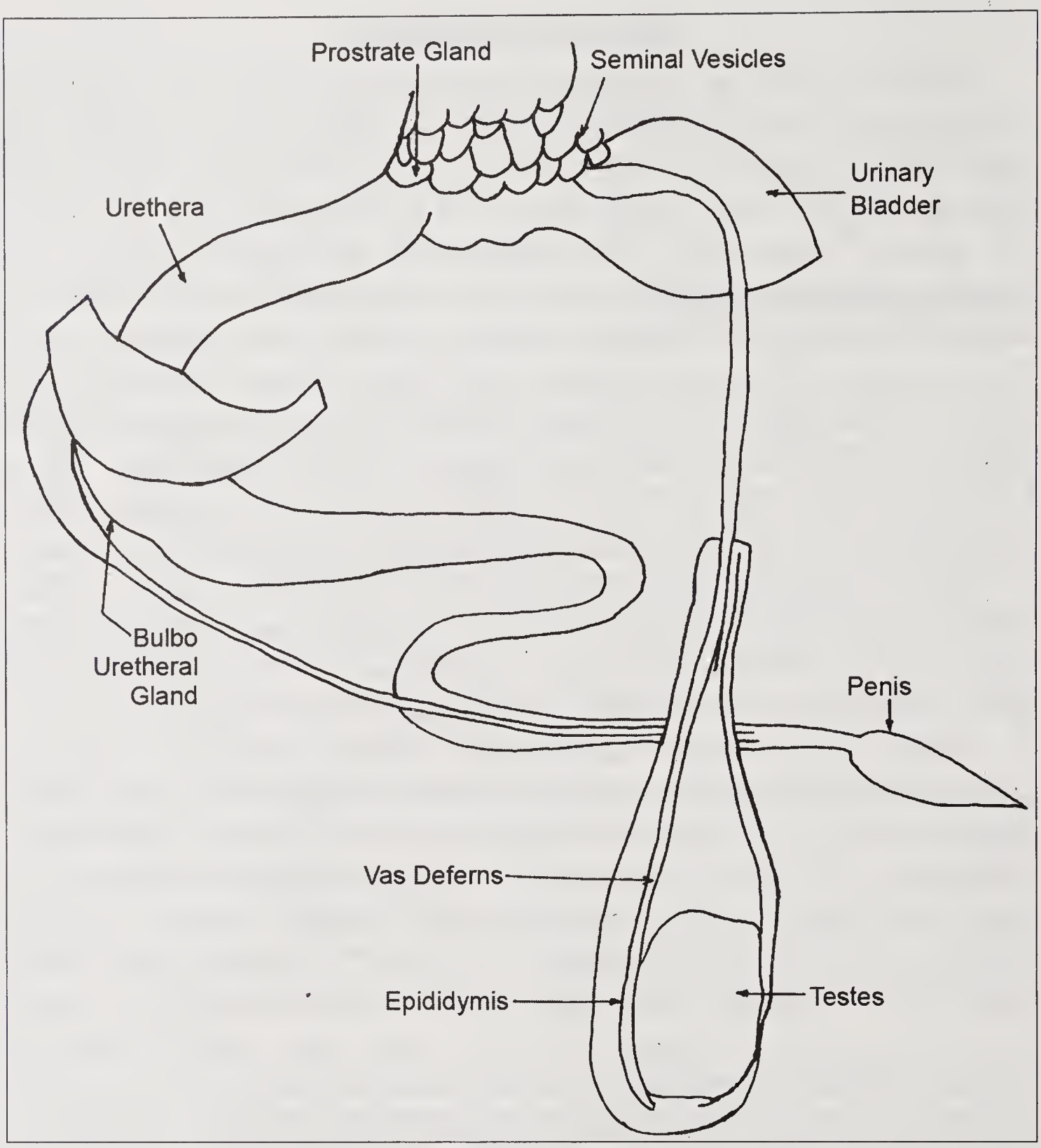

Fig. 7.1 Reproductive organs of ram

frequency of once daily for a period of 20 days. When frequency was reduced to once only or twice in quick succession (3-5 minutes) on every alternate day, the semen of optimum quality suitable for breeding purpose was obtained upto 54 days during Autumn and Spring season from Rambouillet rams (Sahni and Tiwari, 1975a; Kaushish and Sahni, 1977a).

Considering the extent of reproductive wastage in exotic rams in terms of lack of libido (30%), erratic and poor quality semen production (30%), it was observed that about 40% rams could be effectively used for artificial insemination and natural service. About 20-30% of sexually active rams could be used for breeding with the use of electro-ejaculation (Tiwari and Sahni, 1974b). The reproductive organs of ram are shown in Fig 7.1.

Table 7.1 Monthly variation in the reproductive behaviour and semen quality of Russian Merino rams under semi-arid conditions.

Month	Volume (ml)	Motility (0-5)	Sperm Conc. X 10^9/ml.	Reaction time (Sec)	Max. temp. (°C)	Min. temp. (°C)	Relative humidity (%)
January	1.00±0.06	4.20±0.19	2.233±0.26 9	68.70±9.14	26.2	5.3	60.0
February	0.93±0.06	4.00±0.22	3.734±0.606	32.30±15.90	24.7	6.9	54.0
March	1.01±0.67	4.10±0.21	2.993±0.184	72.30±11.33	34.2	14.0	50.0
April	0.97±0.66	3.60±0.27	3.377±0.294	44.60±10.10	37.8	19.1	38.0
May	0.93±0.07	3.40±0.27	2.475±0.294	54.50±10.10	42.9	24.4	19.4
June	-	-	-	-	-	-	-
July	1.14±0.05	3.70±0.22	2.021±0.164	43.70±4.90	37.4	25.2	63.0
August	1.16±0.06	3.30±0.16	2.117±0.174	57.70±6.90	35.9	23.9	84.0
September	1.14±0.07	4.10±0.25	2.205±0.393	56.40±7.60	37.2	20.1	91.0
October	0.14±0.08	4.10±0.30	1.377±0.412	47.10±8.30	33.9	15.1	33.0
November	1.00±0.12	3.00±0.27	1.693±0.227	-	29.4	12.4	68.0
December	1.06±0.06	3.040±0.26	2.186±0.231	108.3±15.8	27.3	5.9	60.0

Table 7.2 Libido and semen quality of Russian Merino rams maintained under various treatments during summer season.

Group	Volume (ml)	Motility**	Consis tency**	Sperm Concentra tion** (Million/ ml)	pH	Reaction time (Sec)	Thrust intensity	Mounts/ ejaculate
Control	0.85±0.05	4.26±0.19	3.23±0.10	1358±137.5	7.44±0.06	25.2±6.06	2.53±0.10	2.10±0.33
	-43	-43	-43	-37	-43		-43	-43
Cooled room	1.06±0.05	3.51±0.23	2.88±0.11	1790±181.9	7.60±0.06	31.9±7.23	2.78±0.06	2.44±0.34
	-50	-50	-50	-45	-50	-50	-50	-50
Animal protein	0.65±0.05	1.31±0.23	2.36±0.14	948±128.9	7.74±0.05	24.9±5.63	2.52±0.10	2.19±0.37
	-36	-36	-36	-31	-36	-36	-36	-36
Trace mineral	0.97±0.07	4.15±0.21	3.14±0.12	1300±128.2	7.52±0.05	28.6±6.14	2.45±0.11	2.48±0.23
	-44	-44	-44	-39	-44	-44	-44	-44

Although with the passage of time and modified managerial practices the progenies of imported exotic parents (Rambouillet and Soviet Merino) appeared to have adapted in relation to semen production but were unable to sustain greater ejaculation stress as compared to native and half-bred rams (Tiwari, 1978; Mathur, 1985). Effect of scrotal wool cover has been studied by Rathore, (1969,1970). Sexual desire and semen production in rams was found to be affected by differential feeding regime. However, inspite of statistical differences in seminal attributes, the semen of optimum quality suitable for breeding operation was obtained in rams of different breeds and crosses, fed ration containing 14% protein in isoenergic ration.

Methods of semen collection in the rams

There are three methods of semen collection.

(1) Anoestrous ewe,
(2) Artificial vagina, and
(3) Electrical stimulation.

Anoestrous ewe: In this method the rams are trained to serve anoestrous ewe and after the service the semen is aspirated from the vagina. It is unsafe to use the semen so collected for fear of contamination.

Artificial vagina: The pattern of A.V. is similar to that in the cattle, except that the A.V. is short. The outer hard rubber casing is 15.0 x 3.75 cm. The A.V. is prepared in the usual way by pouring hot water (45°C) though the inlet on the outer jacket. Necessary air is blown to provide cushioning effect and air valve tightened. Both the temperature and pressure are important. When the A.V. is ready, the inner temperature should be 40°C. Kaushish and Sahni, (1976) considered it advisable to warm the A.V. first with hot water (47-50^{0}C) initially and then pour out and refill the A.V. with hot water at 43- 45°C, depending upon the season, in order to maintain the inner tube temperature between 40-41°C at the time of collection.

A rubber cone is attached to one end of the A.V. at the end of which a graduated 5 ml test tube is fitted to serve as a receptacle for the semen. The open end of the A.V. should be properly lubricated preferably with liquid paraffin. A glass collection cup may be directly fixed to the other end of the A.V. to obtain direct collection. Rams are very sensitive to temperature variations and therefore adjusting, proper temperature in the A.V. is important. Once the rams are exposed either to an A.V. which is too hot or cold, they may refuse to serve on subsequent occasions. A freshly prepared artificial vagina should be used for each collection from a ram to avoid contamination. It should be properly sterilised after the use and kept in dry sterile chamber ready for use.

Electro ejeculation: The equipment for collection of semen from the rams by electrical stimulation as modified by Dziuk *et al.* (1954) is said to be satisfactory. The power is obtained from 110 volt battery with 60 cycles, which is reduced by transformer to 30 volt. This isolates the electrodes from the line of source. The probe for insertion into rectum is made up of rubber hose about 3/4-inch diameter with shoulder rings one inch apart. Alternate rings or electrodes are connected to provide the difference in electrical potential between adjacent electrodes. With this equipment, the collection can be made in standing position. However, at times it is necessary to restrain the animal in an extended position on a table. The rectal probe is lubricated, moistened and inserted so that last ring is located just inside the rectum. The penis may be gently pulled out before stimulation. But on many occasions, it generally protrudes with stimulation. The end of the penis should be held in a glass vial or a test tube. During the process the voltage is gradually increased and then reduced to zero during a five second period followed by an equal period of rest. Stimulus is gradually increased until the semen is ejaculated in the order of 2,5, and 8 volts. The number of stimuli necessary to produce semen is variable.

Merits and demerits of different methods of semen collection

Collection of semen by the A.V. is considered as the best method. Collection by electrical stimulation has an advantage that training of the rams is not necessary. When a large number of rams are to be tested for semen quality, collection by electrical stimulation is advantageous. The major disadvantage in the electrical stimulation is the likely injury to the animal, which can be minimized by the use of the bipolar electrode. Other disadvantages are:

1. Slightly lowered spermatozoa density
2. The possibility of contamination of semen by urine
3. Difficulty in obtaining second collection within short time if the first one is not satisfactory
4. The refractoriness on the part of some rams.

Experience shows that by collection in artificial vagina the volume of one ejaculate is smaller but denser as compared to an individual collection by electrical method. High quality of ejaculates is the main advantage in collection of semen by artificial vagina.

Frequency of collection

Rams are peculiar in their capacity for frequency of ejaculates with optimum quality. Ejaculates to the extent of even 20 to 30 a day followed by successive collections of equal number of ejaculates the next

day have been obtained. Collections to the extent of 2 to 6 per day also have been obtained over a period of a week or 10 days (Chang, 1945). Salamon and Robinson, (1962) observed that season and nutrition did not measurably affect frequency of service nor there was any apparent effect of season on volume, density or sperm count. However, marked effect was seen on these characters due to high protein ration. Satisfactory fertility can be maintained even with frequent ejaculations if the total number of spermatozoa is more than 80 x $10^{6.}$ Fall in lambing rate is observed when the sperm count is reduced.

Evaluation of semen

Colour and consistency: The colour of ram semen is creamy. Variable grades are noticed according to frequency, season, age, rest and among individuals. The normal consistency is thick which is however, evidence about the value of density and motility determinations in rams semen.

Volume: Considering the large size of the testicles in the ram, the volume of semen obtained at one ejaculate is relatively small, on an average it various from 0.5 to 2.0 ml. Wiggins *et al.* (1953) observed that, volume of ejaculates gives a low but significant positive correlation with fertility.

Mass activity: When a fresh drop of ram semen is examined under the microscope at body temperature very brisk dark grey whirls are noticed. The swirling motion is very rapid and dense in appearance. The grading is done as for bull semen.

Initial motility: A drop of semen is diluted in Ringer's or Sodium citrate solution and examined under high power. Gradation of motility is done as for bull semen.

pH: The pH of ram semen varies between 5.9 and 7.3 with an average of 6.4 (Emmens, 1959).

Sperm concentration: The average sperm concentration in a single ejaculate of ram semen contains, on an average, 3 to 5 billion spermatozoa per ml. In a good sample about 90% of the sperms are alive. Ram semen with high sperm concentration is slightly acidic in reaction, while with low sperm concentration it is slightly alkaline. Semen with alkaline reaction is often associated with poor quality and low fertility (Anderson, 1945).

Morphology: A normal ejaculate may contain 5 to 15% of abnormal spermatozoa. A greater proportion of abnormal spermatozoa may lead to poor fertility. The most common forms of the abnormal type are tailless and deformed. Other morphological abnormalities found are: tapering heads, enlarged middle pieces, coiled or bent tails. It is usually

observed that head abnormalities cause low fertility. The types of morphological abnormalities are of more importance than the total sperm count. High percentage of pyriforms or narrow heads is particularly associated with poor fertility. Ram semen with sperm concentration of less than one billion per ml with a pH of 8.0 or higher, with slow sluggish motility and with more than 25% abnormal type and more than 1% abnormal sperm heads are of doubtful fertility and should not, therefore be used for insemination.

Percentage of live spermatozoa: The percentage of live sperms may be estimated by the vital stains (Lasley *et al.,* 1942) or by direct counting. A stain containing congo red and nigrosin gives satisfactory results for ram semen and it is preferred to Eosin and Nigrosin stain (Blackshaw, 1958). The percentage of live sperms is not significantly correlated with fertility in a ram but the percentage of live normal spermatozoa has a significant correlation (Wiggins *et al.,* 1953).

Biochemistry of ram semen

In the ram semen, 1/3 portion is made up of spermatozoa and 2/3 by the seminal plasma. There is marked difference in composition between the sperm and the seminal plasma. Nucleic acid is confined to spermatozoa. The spermatozoa contain more of iron, zinc, copper, haematin, chiefly from the seminal vesicle secretions (Mann, 1964) (Table 7.3).

Table 7.3 Ram semen components (Mann, 1964).

Attributes	mg/dl	Attributes	mg/dl
Dry weight	14,820	Total nitrogen	875
Chloride	87	Non-protein nitrogen	57
Sodium	103	Ammonia	2
Potassium	71	Fructose	247
Calcium	9	Lactic acid	36
Magnesium	3	Citric acid	137
Inorganic phosphorus	12	Ascorbic acid	5

Diluents for Ram Semen

The egg yolk diluent developed by Lardy and Philips (1939) is found satisfactory for ram semen. For this purpose equal volumes of fresh egg yolk and sterilised phosphate buffer (0.2 g dihydrogen potassium phosphate and 2.0 g disodium hydrogen phosphate per 100 ml of pyrogen free triple distilled water) are mixed thoroughly. The pH of the mixture is close to 6.75. If it is not, it should be adjusted by the addition of sterile M/15 citrate buffer or bicarbonate can be used to

replace the phosphate buffer without effect on the glycolysis (Moore, 1949). The replacement of the citrate buffer with glycine has improved the survival time of ram semen (Ahmed, 1955; Roy *et al.,* 1956 and Skolosvkaya *et al.,* 1956).

Milk appears to be the most useful dilutor for ram semen (Istvan, 1956; Foilmom *et al.,* 1956; Macpherson, 1957 and Hill *et al.,* 1958). Miller (1975) reported the use of diluents like egg yolk found to give good results with dilution rate of 1:4.

Sahni (1967) recommended that at least 50 million spermatozoa per dose are necessary for conception in case the diluted semen is deposited in the cervix.

Semen preservation

Successful storage with optimum fertility of ram semen is a worldwide problem. Researches have been carried out to evolve a suitable dilutor for ram semen in this country, but the results obtained are not very encouraging. The glycine egg yolk dilutor has been found to improve the spermatozoa survival of ram semen as compared to egg yolk citrate (E.Y.C.), later Roy *et al.* (1962) observed successful storage of ram semen for a longer period in glycine yolk diluent in the 1 :10 to 1 :20 semen dilutions.

Sahni (1967) in his detailed studies on the storage problem of indigenous ram semen has reported a quite satisfactory survival in heated cow milk and has recommended that cow milk appears to be a dilutor of considerable merit in the preservation of ram semen and also observed it to be significantly superior to buffalo, goat and skim milk. The milk and yolk containing diluents enriched with additives did not show results better than milk diluent alone and Cornell University Extender. Keeping quality of ram semen in these diluents showed significant seasonal variations but generally superior values of motility could still be observed in spring, rainy and autumn season. Effect of higher dilutions (1:1 -1:100) in these diluents up to 72 h of storage interval showed that there has been deterioration in keeping quality of ram semen with the increase of dilution rates beyond 1:10 and effect was more pronounced in egg yolk citrate as compared to glycine yolk and Cornell University Extender diluents on storage at 5-10°C up to 72 h. However, Tiwari, *et al.,* (1968) observed better survival up to 30 h in dilution rates varying from 1:3 to 1:10 depending upon the room temperature in different seasons it could be possible to utilize diluted semen within 3-4 h after collection and dilution for artificial insemination and glucose saline without egg yolk may be used for dilution of semen to be utilized quickly within 2 h of storage at 30 °C.

Ram semen preservation studies (Sahni and Tiwari, 1972), were further carried out, on efficacy of the dilution rates, storage temperature, additives, semen container storage media, cooling rates etc., Results revealed higher spermatozoa survival in egg yolk citrate glucose diluent (EYCG) as compared to EYC, heated cow milk, milk + egg yolk at 8, 24, 48 and 72 h of storage interval. Irrespective of storage media (refrigerator, semen shipper) and the diluents higher spermatozoal survival have been observed in glass screw capped vials. Out of all the diluents tested, EYCG gave higher satisfactory results at different storage interval, which was mainly due to better buffering capacity of the diluent. Further studies were then confined to the EYCG diluents only. Significant differences were observed in percent spermatozoa survival and pH due to variation in number of live and normal spermatozoa (25-400x10^6) in 0.1 ml of diluted semen.. Differences between Rambouillet and Soviet Merino were nonsignificant. Addition of 1,3 and 5 per cent gelatin and polyvinyl alcohol in EYCG diluents did not provide significant beneficial effect on spermatozoa survival and pH during storage.

In other studies carried out by Singh and Saxena, (1965) and Saxena and Singh, (1967), it has been observed that motility and percent live spermatozoa was highest in skim milk yolk followed by egg yolk glucose bicarbonate diluents than EYC and CUE up to 168 h of storage at 3°C. However, during storage there was no auto morphological changes in spermatozoa as reported earlier in EYC diluent up to 72 h of storage (Joshi and Singh, 1968a,b,c) in a comparative study on the efficacy of the diluents have reported higher sperm survival in yolk containing diluents enriched with fructose, tomato juice and glycine, skim milk diluent containing yolk, glucose or fructose. Beneficial effect of caproic acid on sperm motility during storage has been observed by Honmode, (1972).

Sahni and Roy (1972c) studied the effect of deep freezing (–79°C) on post thawing revival of sheep and goat spermatozoa using various levels of glycerol, different equilibration time and rate of freezing in EYC and cow milk diluent. The post thawing survival varied from 10 to 14 percent in different trials and considerable variation between rams with respect to freezability was noted.

The efficiency of EYCG was further compared with diluents prepared from some known buffers by Tiwari *et al.* (1978). Out of many, the percent motility and live spermatozoa was relatively better in diluents prepared from the Mc illvain and Tris buffer containing yolk and glucose similar to that of EYCG. Over and above better survival, the most common characteristics in these diluents were the absence of

sperm clustering (Sperm agglutination) which was about 20-30 per cent in EYCG at 24 h of storage and also relatively better buffering capacity. This shows that these diluents might be able to give better fertility as compared to EYCG diluents.

Deep Freezing of Semen

The limitation in using liquid semen for a longer duration (Maxwell and Salamon, 1993) has necessitated the development of a viable technology for cryopreservation of ram spermatozoa. Concerted research efforts are going on worldwide to improve the methods of cryopreservation and insemination for obtaining, good post-thaw recovery and fertility with frozen semen. The progress made on various aspects of ram semen freezing such as diluents composition, processing, freezing and thawing methods, cryo injury to sperm plasma membrane and fertility has been extensively reviewed (Maxwell, 1984; Evans, 1988; Salamon and Maxwell, 1995 a, b; Watson, 1995; Maxwell and Watson, 1996).

Unlike some mammalian species, ram spermatozoa are susceptible to various stresses during freezing and thawing. Cryopreservation of ram semen depends upon several interrelated factors (Fiser and Fairfull, 1986, 1989; Pontbriand *et al.,* 1989) but their adverse effects are manifested on thawing (Holt *et al.,* 1992). Spermatozoa reach to a state of suspended quiescence for an indefinite period on cryopreservation but can be resuscitated on thawing. However, rather being revived in the same state as they were before freezing, the spermatozoa emerge in a state resembling capacitating. (Gillan *et al.,* 1997), having by-passed some of the normal development process (Amann *et al.,* 1993). "The problem, still, is that even with the best preservation techniques to date post-thaw survival is restricted to about 50 % of sperm population" (Watson, 1995).

The complex anatomy of ewe cervix (Halbert *et al.,* 1990) is also a major factor affecting the fertility with frozen-thawed semen (Eppleston and Maxwell, 1993). Despite of in depth information available on various aspects of ram semen freezing (Salamon and Maxwell, 1995a) the fertility rate after cervical insemination using frozen-thawed semen is low and not acceptable (Maxwell and Watson, 1996; Windsor, 1997). "The low fertility obtained after cervical insemination with frozen semen is caused largely by impaired transport of frozen thawed spermatozoa through the cervix and their reduced viability in genital tract" (Salamon and Maxwel, I995b).

There are two approaches to improve the fertility with frozen ram semen. The first is to improve the procedures for freezing and thawing

semen so that the post-thaw survival of spermatozoa and sustenance of viability is enhanced. The second is to develop better insemination techniques facilitating deposition of semen deep within the cervix or into the uterus (Eppleston and Maxwell, 1993). In order to optimize various variables for achieving high post thaw recovery of motile spermatozoa, there is a need to understand the mode of spermatozoal motion during various stages of cryopreservation. Visual estimates of sperm motion are subjective in nature and cannot specific these changes Budworth *et al.,* 1988; Amann, 1989). Computer-assisted sperm analysis (CASA) is a rapid, accurate and reliable techniques for objective assessment of sperm kinematics (Davis and Siemers, 1995; Holt and Palomo, 1996) and has contributed significantly in the precise evaluation of motion characteristics of short term and long term preserved ram spermatozoa (Ewards *et al.,* 1995; Maxwell *et al.,* 1995; Joshi and Mathur, 1994,1996; Mathur and Joshi, 1994,1996 a,b; Mathur *et al.,* 1997; Joshi *et al.,* 1998; Naqvi *et al.,*1998). However, the validity of CASA. Results depend on careful instrument settings and sample preparation. Therefore for CASA measurements it is ensured that the analyzer is properly set-up and the samples are suitably diluted prior to analysis so that the sperm count of the sample is within the accurate range of the analyzer (Davis and Katz, 1992, 1993; Joshi and Mathur, 1996).

Semen packaging has also important practical implications for cryopreservation (Maxwell *et al.,* 1995). The most common packages for its storage are pellets and polyvinyl chloride straws. Conservation of frozen semen in the form of 0.2 ml size pellets in Egg yolk lactose raffinose citrate glycerol extender with 3 to 4 % glycerol (Joshi *et al.,* 1990) and thawing at 50°C up to liquefaction gave 50-55 % post-thaw motility (Mathur *et al.,* 1991).

Semen extended with organic based diluents and frozen at a linear rate in a programmable cell freezer gives >70 % post-thaw motility when thawed at 50 °C for 10 seconds for 0.25 ml straw and 60 °C for 10 seconds for 0.5 ml size straw. The results were, consistent and reproducible giving an average post-thaw recovery of ³ 70 % motile spermatozoa in rams of exotic (Rambouillet and Awassi), crossbred (Bharat Merino) and native (Malpura) breeds the variable optimized from pellet and straw freezing of Ram semen can be successfully stored in pellets (Salamn *et al.,* 1996) and mini straws (Joshi *et al.,* 1998) for prolonged period of time with no detrimental effect on the subsequent survival of spermatozoa after thawing. Further progress in improving sperm survival would not be achieved simply by modifying the established cyopreservation diluents and protocols (Hammerstedt *et al.,* 1990; Watson, 1995). A more fundamental understanding of the

biophysical and biochemical process that accompany sperm freezing and thawing is therefore an essential prerequisite to the design of successful cryopreservation protocols (Holt, 1997). The application of cryomicroscopy enables direct observations of sperm viability and plasma membrane integrity of ram spem1atozoa during freeze-thaw process (Holt *et al.,* 1988). Observations with experimental cryomicroscopy have shown that freeze-induced membrane damage in ram spermatozoa is manifested after thawing (Holt *et al.,* 1992). During the freezing process, plasma membranes are initially destabilized both by low temperature effects and by exposure to high salt concentrations. The resultant post-thaw degeneration of the plasma membrane is caused by a combination of temperature and osmotic effects (Holt and North, 1994). In order to optimize high post-thaw recovery of motile spermatozoa with intact membranes. Keeping in view, different aspects enumerated below, the strategy of developing the technology of ram semen shall have to be evolved and the scientists are working on these lines.

Sire individuality

The spermatozoa from all apparently healthy rams do not stand the cold shock, therefore, rams have to be screened for this attribute and selected for donating semen for freezing.

Extenders

Neat semen cannot be frozen and revived; it requires certain additives like nutrients, cryoprotectants, cell wall fortifying agents, buffers and antibacterial agents, etc. to be provided. Semen has to be diluted to ensure the required number of spermatozoa per insemination to avoid wastage and to be able to cover more females from one ejaculate. Different workers have developed a number of extenders using different combination of various chemicals having qualities of a good extender but with varying results of conception rate. A good extender should consist of following:

• ***Buffering agents:*** Ram semen has high number of vigorously motile spermatozoa, which consume nutrients very quickly, collect the metabolites especially of the anaerobic respiratory pathway like lactate, pyruvate and lower the pH. Low pH disturbs the electric potential of the sperm cell wall leading to seepage of the enzymes and other material from within the spermatozoa and preventing some from entering into their body, causing toxicity, bursting of the cells and autolysis. To check this, it is important to provide suitable buffering material, which may not allow the pH to go down drastically and keep

it within the tolerable range. Alternately, certain chemicals like cortisole and catalase, etc., which may avoid accumulation of lactate, pyruvate, H_20_2, etc., if provided may give good results. Milk has good buffering capacity but the results in the freezing experiments are not satisfactory. Egg yolk, blood serum albumin and different chemical buffers like tris, glycine, citrate, phosphate, etc., have given good results. Out of these, egg yolk and tris have not become popular. Although electrolytes are helpful at the time of thawing, they are unwanted at the time of freezing.

• ***Cryoprotactants:*** Spermatozoa contain some water. On freezing the volume of frozen semen expands resulting in the bursting of spermatozoa cells and killing them. Cryoprotactants decrease the freezing point below zero degree Celsius, allow the water to make smaller crystals and the chance to pass through that stage quickly. Glycerol, DMSO, ethylene glycol and propylene glycol have been used but varying percentage of glycerol has found favour with most of workers. Higher percentage of it is harmful, because it is reported to deplete the ATP, the energy reserves of the spermatozoa. Cyroprotactants need some time to enter the sperm cell. It is called "equilibration time". Best results have been reported with 1, 4 and 5 h Equilibration time at 4-5°C temperatures. Some workers have different opinion. It must, however be taken care that the cabinet temperature does not go below 0 °C during equilibration.

• ***Cell wall fortification agents:*** Egg yolk, egg yolk extract, lecithin, glutathione, etc., have been commonly used as falsification agents.

• ***Antioxidants:*** Ram sperm cell wall lipids are oxidised quickly on coming in contact with oxygen in the medium or atmosphere and lower the fertilizing ability. Alpha tocopherol, BHT, etc., have been used for the purpose. Boiling water just immediately before preparing the buffers also helps in removing free oxygen dissolved in it.

• ***Osmoregulators:*** Living cells perform well in the media isotonic to the biological fluid they are used to. They should perform well in extender isotonic to semen plasma although certain workers have claimed better results with slightly hyper tonic diluents.

• ***Nutrients:*** Although spermatozoa utilize fructose and glucose in order of priority but maltose, raffinose, lactose, trebalose, etc., have given better results in freezing experiments.

• ***Antibacterial agents:*** Bacteria are practically omnipresent. Spermatozoa like the living cells have to be kept away from bacteria and be controlled by providing suitable antibiotics.

Dilution rate

It includes the number of live normal spermatozoa to be included per ml of the diluted semen per insemination dose, when we are freezing in straws. Normally, ram semen contains 3000-5000 million sperms per ml of the neat semen and only 50-100 million sperms are enough to impregnate an ewe even though only one spermatozoa takes part in fertilization process. In certain extenders used for freezing, dilution rates of 1:2 and 1:3 have given better results than dilution rate of 1:1 which is a general practice for short term preservation or for immediate use.

Rate of heat exchange

It is the most important factor, which needs monitoring. It is important not only to control the rate of exchange of heat at the time of cooling but also at the time of thawing revival. It is clarified by some workers that it should be equal in both the stages and certain workers prefer high rate of cooling as well as thawing, i.e., using high temperature water bath. There is a critical zone of temperature, which is particularly harmful for the spermatozoa and the latter groups in the absence of the knowledge of that zone advise the practice of fast rate of heat exchange. Now a days computer controlled programmable cooling and thawing cabinets are available and the day is not far off when the critical temperature zone will be identified and the measures to pass through it will be devised for successfully freezing the ram semen. Some workers have advised thawing the pelleted frozen semen in media like citrate solution; others however, have found no difference between the results of thawing with or without the medium. Some prefer freezing pellets while others prefer freezing in straws to give wider surface area for quicker heat exchange. Pellets are prepared by dropping 0.2 ml of diluted equilibrated semen in the smooth pits carved on the surface of plastic tray floating on liquid nitrogen allowing it to freeze for 3-5 minutes, collecting the pellets into the goblets and lowering down into the liquid nitrogen for storage. Allowing the liquid nitrogen in direct contact or not has made no difference. Straws have to be filled in the clean cabinet atmosphere of 4-5°C temperature after equilibration, sealed, exposed to certain temperature below 0°C for a particular length of time and then only lowered into liquid nitrogen (-196 °C) for storage. These days small size liquid nitrogen containers are also available for transporting smaller quantities of frozen semen. During thawing, certain workers have claimed good results with as low temperature of water bath as 37 ^{0}C, while some advise as high as 75 ^{0}C. Similarly, the time for exposure may be 10-15 seconds for straws while 1-2 minutes for pellets.

Additives

Addition to the semen of certain chemicals like cortisol, amylase, glucoronidase, which play part in longivity of the spermatozoa in the female reproductive tract and are reported to be deficit under stressful conditions in the tract and their varying concentration in the ram semen with season, individuality, etc., chelating agents like EDTA are also under study to see their effects *vis-à-vis* fertility rate.

Miscellaneous factors

It is reported that semen from rams fed cottonseeds and phospholipids, freeze better. Similarly, the level of certain minerals, vitamins and hormones also do play role on the freezing of the spermatozoa for successful revival. Certain workers are of the opinion that certain chemicals in the seminal plasma are harmful in the process of freezing and hence tried to freeze the washed spermatozoa in artificially prepared extenders but the results are equally disappointing. Feeding, housing and other managemental factors like vaccination, dipping, exercise, shearing, incidence of diseases like blue tongue, sheep pox, etc., affect the semen quality and the composition of seminal plasma and in turn the freezability and fertility. Avoiding sudden change of temperature before equilibration, unnecessary exposure to oxygen and bright light, adhering to strict asepsis at every step using triple glass distilled deionized water, use of pure and nontoxic chemicals are some factors which deserve attention in the venture of deep freezing of ram semen.

The studies on extention rates indicated that Rambouillet semen froze well to give optimum level of cryosurvival and motility, whereas, 3/4 exotic semen showed very poor post thaw survival in both the concentrations and replicates (Mathur *et al.,* 1989).

Factors affecting semen quality

Season: Marked seasonal variations in density, percentage of abnormal sperms and glycolysis in semen of rams was observed by Comstock *et al.* (1945). Poor quality of semen was recorded during summer and early autumn months, i.e., July to September. Bell (1945) observed slight seasonal variations in Rambouillet rams in which semen quality was poor in spring (March-April). It improved in summer (May-July). Koger (1951) found that in autumn, ram semen has higher motility and longer viability on storage than in the semen collected in spring. Maqsood (1951) on his observations on young Suffolk rams reported that during the non-breeding season, there is a marked decrease in the libido, volume and spermatozoa density and increase in the

number of abnormal sperms. Poor libido is believed to be due to interference with the production of androgens by the interstitial cells. Histological examination of testes of the young rams carried during spring and summer revealed arrested spermatogenesis in the majority of the seminiferous tubules. Waston (1952) observed that Merino rams show higher fertility in the autumn but there is uncertainty in the spring. Wiggins *et al.* (1953) found a significant correlation between libido and fertility in the range rams. Volcanic (1953) observed seasonal variations in spermatogenesis in Awassi sheep in Israel. In July and August when days are long and hot, histological examination of testes in rams indicated active spermatogenesis. Whereas from September to December, degenerative changes were noticeable. He considered that the temperature was not the causative factor and implicated availability of grazing facility.

Shukla and Bhattacharya, (1952) observed that the reaction time differed significantly between rams, but there was no seasonal trend and non-relationship to quality of semen. Significant seasonal variations in the volume of semen, pH, sperm concentration, motility and percentage of abnormal spermatozoa were observed. Variations between months and within seasons were also significant. The quality of semen was poorest in autumn and best in spring.

Hafez *et al.* (1955) observed that the quality of semen of Ossimi and Rahmani rams in Egypt was very good during spring and autumn than in summer and winter. Hulet *et al.* (1956) found that ram fertility was 42.8% before September due to poor quality of semen and thereafter, the fertility improved to 67.6%.

Sahni and Roy (1967b) observed in their studies on Romney Marsh rams brought in Uttar Pradesh (India) for improving the indigenous sheep, that in the month of January, the abnormal sperm count was 3.8% but during the months of February, as the climate begins to get warmer, the percentage of abnormal spermatozoa increased to 27.5%. The signs of seminal degeneration gradually developed, as the summer advanced thereafter the initial motility became poor, sperm concentration decreased, more than 90% of the sperms were found dead and the number of abnormal spermatozoa also increased. In the month of June, the wave motion was completely absent, during the months from July to September; there was complete cessation of spermatogenic activity. The semen was devoid of spermatozoa, ejaculates were watery and resembled those obtained from vasectomised rams. The restoration of normal spermatogenesis started from the end of October. There was remarkable improvement in November. The average initial motility was 3.2, the percentage of abnormal spermatozoa came down to 10.6% and

the semen quality was excellent in December and January as in indigenous rams. The semen picture was normal and the abnormal sperm count was only 3 to 4%. These variations in semen quality are attributed to the variations in ambient temperature. It is evident that there is periodic rhythm for spermatogenesis. This pattern is influenced mainly by high temperature leading to deteriorating changes in semen quality, which usually start, from the mid summer. The semen quality gradually improves by mid- autumn. It is not clearly known to what extent the following factors such as available, shade winds, amount of wool on rams, availability of greens, feed, short term heat waves present in some summers and absent in others and frequency of service and/ or collections, influence the semen production.

Decline in semen quality should invariably be accompanied by a gross reduction in the initial motility, sperm count and increase in the proportion of abnormal spermatozoa. It is on the basis of such changes in semen picture of rams in areas away from the equator that a gross decline in semen quality has been reported by Comstock *et al.* (1945), Bogart and Mayer (1946) and Cupps *et al.* (1960). Deshpande (1970) reported that in Bannur x Somali rams, the best semen samples were obtained during spring and winter.

Studies show that shifting indigenous rams even from far distant areas to other tracts which fall within the broad range of tropic and sub tropics do not impair the reproductive efficiency of Mandya rams which were brought to North India from South, an approximate distance of about 1500 km, did not alter their reproductive efficiency. The variations in temperature or duration of daylight had no effect on the production of quality semen throughout the year (Sahni and Roy, 1969).

1. Daylight: Ortavant (1958) studied interaction between temperature and photoperiodism on spermatozoa production. His P- 32 tracer studies in spermatogenesis showed that the rate of division of primary spermatocytes and time of subsequent maturation are relatively unaffected by the photoperiodic environment but the number of spermatids which survive the complete maturation process are affected. The failure rate was observed to be high under conditions of increasing daily illumination. He observed that the effect of high temperature in the spring and early summer months superimposed on this basis photoperiodic effect is to destroy a high proportion of the relatively few spermatozoa which have survived the maturation process. Deshpande, (1970) observed that during spring and winter, the day length varied between 11.02 and 12.56 hours, whereas, the actual day light hours varied from 7.7 to 9.8 hours and the semen quality was best during this season.

*2. **Breed:*** Very little studies have been done on breed differences in semen production and on the interaction between breed, season and temperature. Gunn *et al.* (1942) observed that British breeds in Australia are susceptible to the high environmental temperatures similar to Merino. However, the period of minimum spermatogenesis did not correspond with the high environmental temperature of mid and late summers but were observed in spring. Under Indian conditions autumn appears to be the season characterised with poor quality of ejaculates and summer provides most superior quality of semen, as has been reported in the indigenous breeds like Bikaneri and Mandya (Shukla and Bhattacharya, 1952; Sahni and Roy, 1969; Deshpande, 1970). This is in contradiction to the general trend in temperate breeds reared under temperate or tropical conditions.

Singh and Roy (1963) in their studies on Romney Marsh rams (U.P.) observed that similar to Bikaneri and Mandya breeds, the autumn season is characterised by poor quality semen but unlike these breeds which produce best semen in summer, it is in winter, that the semen of Romney Marsh rams has the best quality. As against this, Emmens and Robinson, (1962) observed that Romney Marsh rams give most satisfactory semen in autumn in Australia. It is due to such differences in response of different breeds to different seasons that Webster (1952), Mies Filho and De Almeida Ramos (1956b), suggested that extreme care is required in choosing rams of right breed for a particular environment. It is not clear whether such limited data is adequate to prove breeds and environment interactions, i.e., differences in sensitivity of breeds to environmental conditions, but gives a sufficient caution before any large scale import of exotic sires is made with an aim to improve the local breeds.

*3. **Altitude:*** High altitude and poor nutrition are deleterious to fertility in rams (Easley, 1951).

*4. **Disease:*** Any infection such as foot rot or abscess, which might cause general febrile condition, will result in seminal degeneration (Gunn *et al.,* 1942). Morley (1948) reported that scrotal fly strike may not necessarily impaire fertility. Engela, (1948) reported incidence of epididymitis, varicocele, scrotal tumors and other diseases of male genitalia, which cause semen degeneration.

Andreevskii, (1940) observed that the main cause of semen abnormality in 40,976 adult rams was chronic orchidoepididymitis. Of these about 15% of rams showed morbid and degenerative changes in the testes, mostly in epididymis.

*5. **Shock:*** Webster (1952) observed that in New Zealand, a cold southerly wind during night rendered large number of rams infertile

overnight and the condition persisted for remaining period of the breeding season. He also observed from the past record that abnormally low lambing percentage was related to a sudden exposure to stormy weather during the mating season.

Dun (1956) recorded temporary infertility in rams, due to damp and marshy conditions, which led to seminal degeneration, associated with flabbiness of the testis. The condition was accompanied by warm humid weather and mosquito plague, shortly before mating.

6. Feeding of thyroproteins: Feeding thyroproteins has not produced beneficial results in rectifying the seasonal effect on ram semen.

Reproductive Behaviour of Ewes

Taneja (1966) has reported a fairly low level of female fertility in Marwari sheep during summer, whereas, a higher fertility rate has been observed during autumn season. It has been suggested that the provision of shelter and off-grazing during noon in summer season may improve the situation. Honmode and Pachlag, (1973) observed increase in chloride content during luteal phase (0.5-0.9%), it decreased (0.4-0.5%) after the heat was over. Reproductive organs of ewe are shown in Fig 7.2.

Table 7.4 Fertility rate in indigenous sheep during autumn and summer seasons.

Seasons	No. of ewes inseminated	No. of ewes lambed	Percent lambed	No. of inseminations per conception
Autumn	67	57	81.1	1.42
Summer	130	103	79.2	1.62

Sahni and Roy (1967a) and Sahni and Sahani, (1973) in a study in the sexual activity in sheep have concluded that tropical sheep, Bikaneri (Magra) is non-seasonal in their sexual activity and about 80-90% come in heat within a span of 20-30 days (Table 7.4). The occurrence of estrous follows a similar trend both in dry and lactating ewes. Estrous length has been reported to be 16-18 days in 65% cases. Duration of estrous varied from 12-36 hours. 80 per cent of lactating ewes came in heat within a post-partum interval of 50 days strongly suggest that neither suckling, nor lactation had any influence on the onset of estrous in Bikaneri sheep.

Tiwari *et al.* (1969d) have studied the incidence of estrous as well as lambing rate as a result of spring mating (April) in Rambouillet, Malpura, Chokla and their crossbred ewes. They concluded that estrous incidences were significantly lower in Rambouillet (4.5%) and

crossbreds (30 to 45%) as compared to sexual behaviour of Malpura (85%) and Chokla (88%) sheep. Lambing rate has been observed to be of the same order. It was studied in exotic breeds by Kaushish and Sahni, (1977a).

Srivastava and Roy (1969) have observed that fertility in adult Bikaneri sheep varied from 74 to 77 per cent when rams were kept with breeding flock for 21 to 31 days. Three lamb crops could be harvested from the same flock within 2 years time by rationalization of management practices.

In a study on the reproductive performance of different sheep during autumn season Tiwari *et al.* (1969c) have reported that 80-85% ewes come in heat during first 18 days of start of heat detection, whereas, 93-100% ewes exhibit their sexual desire in a span of 54 days. The duration of estrous varied between 24- 36 hours in maximum number of cases in all the breeds studied (Rambouillet, Malpura, Chokla, Jaisalmeri, Rambouillet x Malpura and Rambouillet x Chokla). Estrous cycle length varied between 17 and 19 days with maximum concentration on 17th and 18th day. In case of Rambouillet and their crossbred there was a tendency for cycle length to occur between 16-17 days.

Tiwari and Sahni (1974b) and Tiwari *et al.* (1969b) have observed that the mean post partum heat after 36.5 days in Malpura as compared to 41.6 days in Chokla sheep. The values for postpartum conception interval were 61.4 and 66.7 days in above breeds, respectively. It has been concluded that 50-60 per cent of native sheep could give a second crop of lambs, if rebred between 45 to 90 days postpartum.

Tyagi and Lavania (1965) have reported a significant difference in the breeding season in different sheep breeds. Higher environmental temperature was more suitable to indigenous ewes and comparatively lower temperature to crossbred ewes, whereas cooler environment is necessary for the Polworth sheep. Relationship between monthly mean bright sunshine hours and percent ewes bred indicates that increase in reproductive activity followed by the decrease in bright sunshine hours. Rainy, autumn and early winter have been recommended for breeding sheep.

Honmode *et al.* (197lc) in a study on the investigation into the effect of season, hormone and plane of nutrition on reproduction and characteristics of wool of indigenous sheep breed, have observed that thyroxine feeding showed a favourable effect on lambing percentage. Results on the reproductive behaviour of six breeds of indigenous sheep on low and high plane of nutrition revealed that nutrition had no effect on estrous cycle length (19-57 days). Ovulation time has been observed to vary from 28 to 36 h after the onset of heat.

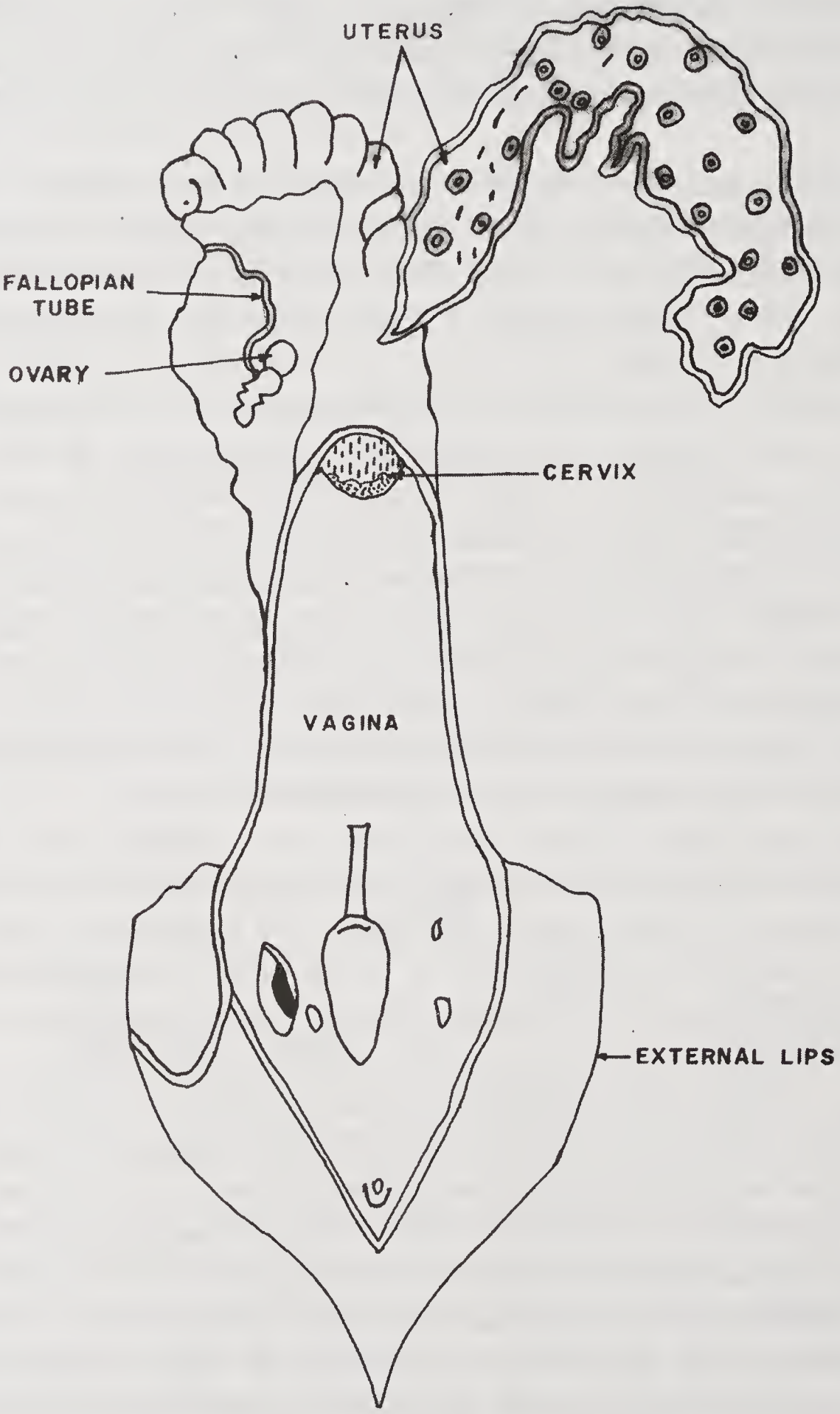

Fig. 7.2 Reproductive organs of ewe

Tiwari and Sahni, (1974a) have observed that the provision of housing has no beneficial effect on the sexual behaviour of young cross bred ewes.

Sahni and Tiwari, (1972) in a study on the reproductive behaviour in young ewes of various sheep breeds have observed that majority of native ewes showed their sexual desire at the age of one year as compared to 1.5 years and 2 years in cross bred and exotic ewes, respectively. Lambs born in autumn season attain maturity earlier than

the spring born lambs. They made a comparative study of the reproductive behaviour of certain native, exotic and cross breeds of sheep under tropical conditions. High environmental temperature of summer had no adverse effect on fertility of native or cross bred sheep. The Corriedale when provided with some protection against intense heat of summer could be considered as the one exotic breed capable of satisfactory reproduction under tropics.

Several workers have observed Biochemical changes in blood, vaginal mucus and oviduct. Rawat *et al.* (1987) observed depression in thyroid status on day 3, but it was more on day 16 of the cycle than on any other day of the estrous cycle, these differences were not significant. Rawal *et al.* (1986a) observed that the pH of vagina on 16th day and zero hour of estrous were close to neutrality, while it tended towards alkalinity at 8 h of estrous. The pH values followed increasing trend from zero to 8 h and then decreasing trend continued till 16th day of estrous. The values of ratio between vaginal mucus potassium and sodium and total sodium and potassium to chloride and pH value at 8th h of estrous showed that pre- estrual secretions are not quite conducive for sperm survival.

Fluctuations in the mean glucose, pyruvate, lactate, glycogen, total carbohydrates and activity levels of lactate dehydrogenase, glucose-6-phosphate dehydrogenase, phosphorylase a and b, acid and alkaline phosphatases and structural soluble and total proteins, DNA, RNA and total lipids in oviduct and vaginal tissue homogenate during various phases of estrous cycle were studied by Rao *et al.* (1987).

Sahni and Roy (1972d) studied variation in postpartum conception interval in Bikaneri flock in which matings took place continuously over several years, gave an average conception period of 183.6 days indicating that, normally it is not possible to obtain more than one lamb from each ewe given by the one third of the flock within a period of 12-15 months is counter balanced by an equal proportion of ewes which take very long time to conceive again even when rams are run continuously.

Puberty

Puberty in the males is marked by production of viable sperms and a desire for mating influenced by hormone, testosterone. The age at puberty varies from 132 days for Tobasco (Pelibuey) x Dorset lambs on the high plane of nutrition in Mexico (Valencia *et al.,* 1977) to as old as 738 days for 3/4 Rambouillet 1/4 Malpura lambs in Rajasthan (Tiwari and Sahni, 1981). The quantity and quality of ejaculates collected from puberscent rams are poor with a high incidence of dead and deformed spermatozoa (EL-Wishy, 1974).

A similar desire for mating also takes place in the female. Puberty in the female is exhibited by the first estrous. The breed of the ewe affects the age and weight at puberty and sexual maturity. Ewe lambs in most of the mutton breeds reach puberty at the age of 10-12 months, normally breeding during the first autumn. Larger, slower maturing breeds may mature at the age of 18-20 months.

Awassi lambs on a good diet first display estrous at an average age of 274 days (Younis *et al.,* 1978) but Rambouillet crossbred lambs in Rajasthan are about 615 days old before they display estrous (Kishore *et. al.,*1982). This difference is largely due to the different growth rate resulting from different nutrition. The average age at puberty in Ossimi and Barki ewe lambs reared on high plane of nutrition was 347 days in Egypt, whereas, it was 366 days on a low plane of nutrition (El-Homosi and EI-Hafiz, 1982). The variation in age at puberty occurs in sub-tropics where the ewes are reasonably anestrous so that if a lamb fails to cycle in her first season she will not cycle until the next, several months later.

Under Indian conditions, the ewes reach sexual maturity at 9 to 14 months of age, however, the full body growth is only attained between 18 to 24 months of age and the stage at which the mating is performed. Merino sheep mature more slowly than the Hampshire or Suffolk breeds, crossbred lambs generally mature earlier than purebred lambs. Roy *et al.,* (1962) recorded first estrous in young Bikaneri ewes of less than one year of age. Majority of the Nellore ewes attain puberty at 630-810 days of age (Gupta *et al.,* 1987). The age at puberty has been reported to vary from 306-383 days in different exotic breeds (Martemucci *et al.,* 1983).

The Estrous Cycle

Rhythmic sexual behaviour patterns develop in females during puberty. This change in behaviour is called estrous and it occurs with each estrous cycle in non seasonal breeders unless pregnancy intervene. The combination of physiological events, which begin at one estrous period and end at the next, is termed as estrous cycle.

The ewes, indigenous to temperate areas, during breeding season, estrous occur every 14-19 days with a mean of 17 days (Terrill, 1974). Similar duration has been observed for ewes in tropics by Narayanaswamy and Balaine, (1976); Gaillard (1979) and Yenekoye *et al.* (1981). Cycle lengths of up to 70 days were recorded for Fulani ewes in Niger by Yenikoye *et al.* (1982).

Visual signs of approaching estrous are, a swelling and redness of the vulva and restlessness or nervousness indicating a desire for company,

but the most obvious sign is ridding and inturn being ridden. The breeding occurs only during estrous although the ram is capable of breeding at any time (Dhanda, 1970).

Three types of estrous cycles commonly observed are: (i) First type is seen in sheep, goats, cows and sows during breeding seasons. The infertile cycle in these species culminates in spontaneous ovulation of mature follicles; *corpara lutea* automatically formed, becomes functional and exists for a definite period of time. (ii) Rat and mouse are example of second type of estrous cycle in which ovulation is spontaneous, but the *corpus leuteum*, which is formed is not functional unless mating occurs; and (iii) In third type maturation and ovulation of follicles fail unless the male copulates with the female. Rabbit is an induced ovulator.

The main events of the estrous cycle of the ewe can be divided into those associated with the growth of follicle and those associated with the growth of the *corpus luteum*. The growth of the follicles takes place during proestrous and estrous. The period of the corpus luteum can be divided into two periods, metestrous and diestrous. The estrous cycle is usually dated from the first day of estrous.

1. Estrous

Estrous is defined as the period of sexual receptivity during which ovulation occurs in most species and the corpus luteum begins to form. The psychic estrous is brought about by the action of estradiol on the central nervous system. Symptoms of heat are less pronounced in ewe than in cow or mare. The ewe in heat makes little effort to tease and mount. Because of weak symptoms, it is difficult to detect estrous in ewe. The duration of estrous in ewes varies from 12-72 h (Taparia, 1972; Castillo Rojas *et al.,* 1977; Gaillard, 1979; Yenikoye *et al.,* 1981) with an average of about 45 h. Breed of ewe does not affect the duration of estrous. Ewe lambs, usually have the shortest estrous, older ewes have the longest and the yearlings are intermediate. The duration of the estrous cycle is shorter at the beginning and at the end of the breeding season.

The first ovulation at the onset of puberty is frequently not associated with psychic estrous. It appears that a small amount of progesterone is necessary to trigger psychological estrous. In the cycling ewes this comes from the corpus leuteum of previous cycle. Therefore, the first ovulation after the ovary is awakened from the quiescent state finds the ovary without an old corpus leuteum to produce the small amount of progesterone necessary to bring about psychological estrous.

The ovulation takes place about 12 h before the end of estrous. Right ovary ovulates more frequently than the left, 60 and 40%, respectively.

During estrous swelling and reddening of vulva occurs. Ewes become restless. Pheromones begin to appear during proestrous. Ewes normally come in heat after the weaning of lamb. Some non seasonal breeding ewes may show a post partum estrous a few days after delivery, but others wait for 4 to 6 weeks.

Two to 3 days before the onset of estrous grafian follicles destined for ovulation begin to enlarge rapidly and become turgid. The theca interna hypertrophies and the ovum, with attached cumulus oophorus, moves from the embedded position in the granulosa layer toward the enlarged fluid filled antrum of grafian follicle. A transparent area appears in the follicle membrane near the apex when ovulation is impending.

2. Metestrous

The ewe enters metestrous after estrous. This phase lasts for 2 days. The corpus luteum organises during this period and becomes functional. The progesterone level rises rapidly.

3. Diestrous

Diestrous is the period during which the influence of luteal progesterone on accessory sex structures predominates. This phase is referred to as the phase of the corpus luteum. Metestrous and diestrous are referred to as the luteal phase. Large amounts of progesterone enter general circulation resulting in the development of endometrial growth and also of mammary glands. The myometrium develops under the influence of progesterone and the uterine glands secrete a thick viscous material, which will nourish the zygote. If a zygote reaches the uterus, the corpus leuteum continues through out pregnancy, but if the ovum is not fertilized, the corpus leuteum remains functional only until day 12 or 13. The decline of progesterone permits a surge of FSH and growth of another follicle, resulting in initiation of new estrous cycle. In short, the estrogen dominates for 3-4 days of cycle and progesterone dominates for about 13 days.

Development of corpus luteum: The corpus luteum is a temporary endocrine organ which functions for only a few days in cycling non pregnant ewes and thoughout the duration of pregnancy once the ewe becomes pregnant. The corpora lutea of sheep reaches maximum size by day 3 and at this time it is reddish pink. Corpora lutea becomes paler as dioestrous approaches and after day 14 degeneration is rapid. Because the estrous cycle of the ewe is shorter, the corpora lutea of the ewe are devoid of the lipochome pigment, hence the lighter colour. The circulating levels of progesterone in plasma during follicular and luleal phases are 0.25 and 3.7 ng/ml in ewe.

4. Proestrous

It is the period after which the corpus luteum fails, when the progesterone level drops, FSH release stimulates follicle growth and rising estrogen levels lead to estrous. Proestrous and estrous are often referred to as the follicular phase. Estradiol increases the blood supply to the tubular genital tract from vulva the uterine tube and causes oedema. The vulva swells, the vestibule becomes hyperemic and the glands of the cervix and vagina secrete a serous secretion, which appears as a vaginal discharge.

Anterior pituitary and the gonads: The primary target organs of the pituitary gonadotropins are the ovary and testes. The growth and development of ovarian follicles in mammals are dependent upon FSH but LH is essential for follicle maturation. Both FSH and LH are essential for the synthesis of estrogen. Rising estrogen blood levels suppress release of FSH and facilitate release of LH.

Apparently the anterior pituitary throughout estrous cycle secretes FSH and LH continuously, but the proportions and levels of each, change during the different stages of the cycle.

Estrogen in large quantities inhibits FSH secretion. PGF_2 alpha from non pregnant progesterone dominated endometreum reaches ovary by a local route between day 14 and 15 and kills the corpus luteum. The progesterone level falls and FSH level increases. The peak of FSH can be seen just before estrous. FSH facilitates follicular growth and quick estrogen production. The rising estrogen induces behavioural estrous and triggers a release of an ovulation surge of LH on the days of estrous. Estrogen levels then decline but the new corpus luteum starts progesterone production, which rises during the next few days and is sufficient to hold gonadotropin release to low level. On day 16, the corpus luteum is killed again and the cycle is completed.

Factors affecting corpus luteum: In polyestrous domestic animals, corporalutea develop after ovulation and function for 14-15 days unless pregnancy occurs to signal the corpora lutea to continue functioning. There appears to be marked species differences in the control of corpora luteal function. The pituitary is needed in most species to produce luteotropin at ovulation to form the corpus luteum. No pregnant uterus produces a substance probably PGF_2 alpha, which has a luteolytic, influence on the corpus luteum. The luteolytic effect of uterus is dominant to hypophysical control of the life of the corpus luteum in sheep. Presence of an embryo in the uterus will prevent luteolysis. Researches have shown that an embryo must be present in the uterus by the 12th day of the cycle in sheep if luteolysis is to be avoided. Luteal regression can be prevented in the ewe and cow by uterine infections.

Presence of intra uterine devices (IUD) shortens, the estrous cycles in sheep and cow.

Artificial Insemination

During the recent years, it has become necessary to breed sheep by artificial insemination for making intensive use of superior sires. USSR is the foremost country in the world where thousands of sheep are annually bred by artificial insemination. Kenya, South Africa, Romania, Australia and Argentina are other countries where limited use of this method of breeding is being made in selected flocks. In India, it has been tried with success on sheep breeding farm at Poona by Sane *et al.* (1952), at Indian Veterinary Research Institute by Guha *et al.* (1951); Shukla and Bhattacharya (1952) and Roy and his colleagues (1956) at Mathura on experimental basis.

The practical methods of AI are broadly classified as: (i) Vaginal insemination (ii) Cervical insemination (iii) Intrauterine insemination and (iv) Transcervical insemination. These methods differ from each other in their effectiveness, cost and complexity and have been tried with varying success by different workers (Salamon and Maxwell, 1995b). The first two methods involve the use of fresh diluted or short term preserved semen, whereas, the next two are complex and generally used for frozen semen. Fertility following AI with frozen semen is limited by the inability of frozen-thawed sperms to transit the cervix. Even when very large number of motile spermatozoa is deposited in the cervix, fertility is lower for frozen semen than for fresh semen (Maxwell and Hewitt, 1986). The cervical canal contains 4 to 5 funnel shaped rings with the smallest opening caudally and one or more of them are eccentrically aligned to the rest of the canal (Halbert *et al.,* 1990). The other factors, which also affect the fertility, are insemination dose, site of insemination and time of insemination (Salamon and Maxwell, 1995b).

Laparoscope IUAI radically improves the fertilization rate with frozen-thawed semen and has potential for widespread dissemination of valuable genotype because of economics in semen use. An average ejaculate diluted appropriately can be utilized to inseminate 50 ewes. With the aid of laparoscope, the semen is directly deposited into the lumen of uterine horn and thus circumventing /by-passing the cervical barrier (Killeen and Caffery, 1982). This method has invariably improved the fertilization rate over cervical insemination using frozen-thawed semen when done at an appropriate time in relation to ovulation (Maxwell, 1986).

Ewes after sedation are restrained in a locally fabricated cradle and suspended in a head down position at an angle of 45°C. Two small incisions are made using angular blades and trocars at each side of mid ventral line are introduced. Through one Trocar, and through other laparoscope is introduced into the abdominal cavity and uterine horns are located. A modified Allis forceps is introduced through another puncture site. The uterine horn is grasped gently and lifted upto the skin surface to expose a small loop. Semen is loaded in modified aspic and deposited into the lumen of both the horns one by one. The procedure takes only 3-4 minutes.

Although, direct deposition of semen in uterus with the aid of laparoscope has resulted in acceptable lambing, but the cost, skill, complicacy and minor surgery involved in the procedure limits its greater utilization. Alternatively a transcervical AI technique known as Guelph system of transcervical AI (GS-TCAI) has been developed in Canada (Halbert *et al.,* 1990; Buckrell *et al.,* 1992). Concerted efforts are going on in major sheep rearing countries to develop this simple, cost-effective and non-invasive transcervical AI technique in order to penetrate the cervix and achieve acceptable lambing with frozen semen.

A simple equipment ideally suited for transcervical AI is (a) Spinal needle with a screw end which was suitably modified to fit to the AI gun. The other end of the needle was shouldered, made blunt and bent at an angle of 45° (b) An AI gun utilizing 0.5 ml straws modified to a length of 28 cm. A screw was soldered to the anterior end to adapt the needle head; (c) Vaginal speculum, fabricated using a hard plastic cylinder, with an outer diameter of 2.5 cm and length 15 cm with a slit (1 cm) at one end and provision for a battery operated light source on the opposite end; (d) Cradle was fabricated using a piece of tractor tyre of 1.2 m length, 0.26 m width and 0.22 m height.

For transcervical AI with this equipment, the ewes exhibiting oestrous are restrained at a dorsal position in the cradle with the hindquarter elevated so that the vulva is positioned at an angle of 80 to 90° from the ground. The lubricated speculum with plunger is introduced into vagina and the external os is located after removal of the plunger with the aid of the light. The needle is gently introduced into cervix and manipulated into the deepest location possible. The depth of cervical penetration is subjectively graded in the scale of (1-3) as 1: no penetration -os, 2: shallow to deep cervical penetration-mid cervical and 3: needle inserted to its full length-uterine deposition. Out of 47 cervical penetrations performed with this equipment, grade 1, 2

and 3 penetrations were achieved in 14.8, 40.4 and 44.7% ewes, respectively. Following Tran cervical AI with frozen ram semen after grade 2 and 3 penetrations (Naqvi *et al.,* 1998), success has been achieved for the first time in this country in terms of lambs born.

Breeding by Artificial Insemination is now being practiced in various sheep breeding farms in India. The main consideration in adopting this method of breeding in sheep is to use sires having the desirable traits especially for quality of wool and meat. The inherent danger of transmitting undesirable traits though sires, which have not proved, should not be overlooked. The possibility of transmitting undesirable recessive characters due to widespread use of unproven sires though artificial insemination is a matter for consideration.

Artificial insemination (AI) of sheep has been in extensive use for over the last six decades in major sheep rearing countries (Evans 1988). It is being applied in a variety of means to increase the genetic merit of sheep flocks. These include: (i) to increase the selection intensity of rams, (ii) to monitor genetic progress by allowing comparisons between flocks and between sires, (iii) to allow access to superior sires and (iv) to allow widespread use of superior sires and avoid the possibilities of contagious diseases within the flocks (Abbot, 1994). Other major benefits include the ability to collect and cryoconserve semen to ensure against the death of a genetically valuable, or to maintain a flock's genetic diversity without retaining live sheep (Windsor 1993). A data based on conservative estimate has shown that the potential number of lambs sired by a ram each year using AI with frozen semen is 24 times higher than AI with fresh semen but in comparison to natural mating it is 545 times higher (Maxwell, 1984)

In flocks, where it is not possible to synchronize the breeding season naturally, it results in a prolonged lambing season with the consequent lowering of uniformity of the lamb crop. This method of breeding is very expensive but considering the large scale development in economic characters, adoption is most essential. The method may prove economical in case of large number of flocks, where grading is desirable are concentrated in a locality and where there is dearth of quality rams for breeding purposes.

The age of sheep influences the fertility to a great extent in terms of ovulation rate and fecundity. Variation in fertility has been observed in different sheep breeds. Fertility per cent in Muzaffarnagari varied from 64.0 per cent (1-2 year) to 85.3 per cent (4-5 year) in different age groups (Sinha and Khan, 1989).

Selection of rams

It is possible to select rams initially on their phenotypic characters coupled with judgment on qualitative requirements for wool and meat. However, most of the economically important characters of sheep are highly heritable and as such selection can be made on phenotypic characters. Selection has to be done at an early age, as low as six months or so. They are usually ready for service at about nine months to a year. At this stage it is possible to study the sex behaviour and quality of semen. In case this is up to the mark, progeny testing should be done to evaluate their potentialities. Progeny tested rams can further be used on mass scale. Limited use should be made in case rams are not progeny tested for fear of transmission of undesirable traits, especially lethal and sub lethal characters. It is desirable to use rams with very high fertility rate so that the flocks can be settled in a reasonable period of about 60 days under natural mating.

Management of rams

Ram sperms take 40 days to mature. The sperm cells, which are required for A.I. programme, are developed during two months prior to their collection.

Most of the insemination programmes are carried out from mid February till mid May. As this is the period when ewes are normally cycling. However, most of the semiarid areas experience very hot summers, resulting in summer infertility.

Rams, should have access to pasture or irrigated plots and before they are let out on pasture, should be inspected daily for fly strike, screwworm and foot abscess. Rams at two-tooth stage are separated from adults to prevent fighting and homosexuality.

When the actual insemination programme starts, the rams are still housed and fed as before and walked to the shearing shed and back daily, to ensure exercise. When in use at the shearing shed, they are penned separately awaiting their turn as semen donors to avoid fighting with other males and to save time in handling.

The training, actually does not begin till the programme starts and it seldom takes more than two days to get all rams to serve an ewe and subsequently into an A.V. The number of collections to be obtained in a day varies from ram to ram. From most of the rams, semen can be collected three times a day producing average ejaculates of 1.0 ml, sperm concentration of 35×10^8 per ml and live counts 85-90% (Miller, 1975). He further reported $15{,}000 \times 10^6$ sperms per day from two teeth rams in three collections (Table 7.5).

Table 7.5 Results of rams semen examined on day 6th and 15th day of semen collected.

Rams	Vol. (ml).			Sperm No. ($x10^8$)			Live (%)		
	No.1	No.2	No.3	No.1	No.2	No.3	No.1	No.2	No.3
Day-6									
Ram A	0.7	1.4	0.8	39	45	45	90	92	88
Ram B	1.0	1.0	1.1	41	31	31	90	86	88
Ram C	0.8	0.6	0.5	34	45	45	82	95	95
Ram D	0.7	1.0	0.4	54	43	36	95	95	95
DAY-15									
Ram A	0.6	1.0	0.8	40	40	35	90	90	90
Ram B	1.0	1.0	1.0	40	35	30	90	85	90
Ram C	0.0	0.6	0.4	32	40	45	80	90	95
Ram D	0.7	0.5	0.7	45	40	35	95	95	90

Semen could successively be collected up to 5 times daily for 17 days from mature rams without fall in semen quality (Miller, 1975).

Management of ewes

Keast and Morley (1949) and Dun *et al.* (1960) recommended overnight teasing and drafting raddled ewes off in the morning. This is quite manageable for small lots, but when large numbers have to be inseminated, it takes lot of time, as ewes cannot be presented for A.I. at proper time during estrous. Under the circumstances the rams have to be worked too frequently to provide necessary semen. When large number of ewes is to be handled, harnessed vasectomised rams are released with the ewes at about 5 PM and the mob turned into a paddock. They are mustered into the yards by 8.00 AM the following morning and marked ewes drafted off. With few modifications to most sheep yards, this can be done at the rate of 4,000 per hour.

Marked ewes are either inseminated to get the labour force acquainted with procedure and a few rams checked and trained or these are put aside and brought back into the mob at the end of the cycle. Generally, the drafted ewes are inseminated on the acceptable type of estrous mucus. Obviously those ewes, which are drafted late in estrous, are rejected (Table 7.6).

After the morning draft the remaining flock is redrafted at 4.00 PM These ewes, which are called as "A ewes" have commenced estrous between 9 AM and 4 PM The main flock is returned to the paddock with teasers and brought in for drafting again the following morning. The marked ewes, which are called as "B ewes", have commenced estrous between 4 and 8 AM

Table 7.6 Percentage of ewes in heat according to duration of estrous.

Breed	12-24 h	24-48 h	48-72 h	72 h and above
Jaisalmeri	45.00	40.00	13.00	1.80
Malpura	28.00	52.50	16.00	2.50
Chokla	20.60	49.00	31.70	4.70
Rambouillet x Chokla	40.80	40.30	12.50	1.80
Rambouillet x Malpura	36.60	45.80	13.70	3.60
Rambouillet	43.20	15.40	9.56	1.89

The "A. ewes" are inseminated between 7 to 8 AM the following day. The "B. ewes" are inseminated between 10 AM and 3 PM the day they are drafted off. All the "A. ewes" are inseminated between 15 and 23 hours after the onset of estrous. All the "B. ewes" are inseminated between 2 and 23 hours after the onset of estrous.

Vasectomised rams

The number of vasectomised rams used is 1% of the original number of ewes i.e. 5,000 ewes 50 teasers and even when there are only 1,000 ewes left in the mob, 50 teasers should still be used. All vasectomised rams are tested for brucellosis. Two teams of teasers are used and alternated every 3rd day. The time to change teasers is when a large percentage of dry ewes that are presented for insemination have creamy vaginal mucus. This indicates that estrous has terminated and this means that teasers did not detect estrous at the onset, either because there were too many ewes or they had lost interest.

Management calendar

Rams, which are well fed and well grown, may become functional as early as 8 months of age and produce viable sperms. It is difficult to assess their merit as sires for wool production under the age of 12-14 months. The two tooth performance is the best guide of suitability for use as sire. Selection for mutton characteristics can be done at an early age as growth rate is the important criteria. Waston *et al.* (1956) observed that testicular development could be correlated more with live weight of the ram than with age.

Storage and transport of semen

Yoshika *et al.* (1951) reported that ram semen can be successfully stored for seven days with high fertility rate. Temperature of 4°C is reported to be optimum for storage of ram semen (Moore *et al.,* 1940). Storage of ram semen at 20°C in the presence of CO_2 is also considered

as good (Blackshaw, 1958). Sudden temperature changes are considered harmful for the viability of the sperm. Semen should be cooled gradually for storage. Blackshaw, (1958) reported that the presence of egg yolk in the diluents is largely responsible for preventing the cold shock.

The metabolism of ram semen is mainly glycolytic (Mann, 1964). Salisbury, (1946) reported that the metabolism of ram semen is mainly glycolytic, oxygen may damage spermatozoa. Complete anaerobic condition is therefore necessary for storage. The viability of ram semen is prolonged with effective exclusion of air during storage. It is preferable to seal the ampules with minimum air space as far as possible to avoid agitation during transport.

Insemination technique

Under the insemination technique there are a number of prerequisites such as equipment for insemination, restraint of ewes, number of ewes for insemination and adjustment of inseminations during better part of estrous period end whether heterospermic inseminations are desirable or not.

Equipments

A speculum, a head light torch and a syringe with insemination pipette is all the equipment required. There are three types of specula in use (1) the duck bill type, (2) metal barrel, and (3) glass speculum. It is the usual experience that the duckbill type is easy for insertion and gives greater ease and freedom of movement. It can be easily dilated in the vaginal passage and removed in a closed condition after use. It is also easy for sterilization. A glass speculum is also used. A 2 ml glass syringe attached to inseminating pipette with a rubber connection is most convenient for insemination. A fresh insemination pipette should be used for each insemination.

Restraint of ewes for insemination

With the help of two attendants, ewes can be inseminated at the rate of 100 per hour, if the operation is streamlined, using fresh neat semen. Various methods of holding ewes have been used and some methods used in Australia between 1950 and 1960 are give below:

- Ewes held upside down in a cradle.
- Ewes placed on a battery of bails on a raised platform.
- Ewes held on a rail, as for lamb marking.
- The operator working in a pit and a ewe maneuvered upto a hock bar at the edge of it.

Other methods used in Asia and in South America, include the use

of various cradle and jacking devices to lift the hindquarters. These are not easy to operate. The method used in Australia, at present, is for the attendant to saddle the ewe facing the tail and with a hand under each flank to throw her hindquarters over a rail 24" above floor level. Attendant keeps the ewe's hind legs extended by pressing into her stifles. If the ewe's front feet are on the floor, she will not struggle. After insemination the ewe is released through a gate in the pen.

A false floor about 2 feet high is put into the catching pen to enable the inseminator to have the ewes presented at eye level. When the ewe is placed over the rail, an assistant inserts a glass speculum whilst the inseminator loads his syringe. The inseminator then holds the speculum, locates and positions the cervical opening and inseminates the ewe. The semen is deposited in the cervix.

A simple wooden crate with sloping platform is considered for restraint. The rear portion is raised to a height of 3 feet so that the inseminator can conveniently inseminate in standing position (Sane *et al.*, 1952).

Time of insemination

During estrous, mucus flows freely from the cervix into the vagina. Generally, there is a small amount of clear mucus at about the time estrous commences, but as estrous advances the amount of mucus increases and its nature changes. It first becomes cloudy, then creamy and finally cheesy in consistency (Table 7.7). Although, it is usually considered that changes occur progressively as estrous advances, these cannot be used to time different stages precisely. However, Morrant and Dun, (1960) have demonstrated an association between fertility and the different types of mucus at the time of insemination.

Table 7.7 The fertility of ewes with different types of vaginal mucus

Type of mucus	Grade	Fertility (%)
Clear and sparse	1	50
Clear and copious	2	62
Cloudy and copious	3	62
Cloudy	4	52
Creamy	5	33
Cheesy	6	15

Uterine contractions and motility of the spermatozoa are largely responsible for quick transport of spermatozoa though the tubular genitalia to the fertilization site in about 2 to 4 minutes. The ova are reported to survive from 12 to 23 h in the fallopian tubes but it is not

very clear if they are fertilizable during this period. Generally, 8 to 10 h appears to be a reasonable time for the survival of tubal ova. Therefore, inseminations done any time within the estrous period may result in fertilization with the greater possibility of success to insemination done during mid estrous and least possibility in the later part of estrous i.e. close to ovulation time.

Sinclair, (1957) confirmed this concept based on his studies on 1500 Merino ewes bred naturally or by artificial insemination in early, mid or late estrous. Conception by natural mating at each stage resulted in 55-65% fertility. Lower conception rate resulted due to inseminations in late estrous when the cervical mucus was becoming creamy. The observations of Corbonero Bravo (1955) show that the optimum time of insemination was mid estrous, i.e., 12 to 18 h after onset of heat. Osikoski (1965) obtained highest lambing percentage 12 h after the onset of estrous even by natural service in 175 mountain ewes and 8 hours after in 122 Merino ewes. There was no difference in the conception rate of ewes (53.2%) between morning and evening inseminations based on 45 day non returns (Mies Filho and De-Almeida Ramos, 1955 a).

Seasonal influence on successful percentage of inseminations

Season of the year has a marked influence on the successful percentage of insemination. Dun *et al.* (1960) observed significant differences in favor of inseminations done during autumn season. Salamon and Robinson, (1962) observed 20-25% more lambing crop in ewes inseminated during autumn as compared to those inseminated in spring. The difference is not due to differences in semen quality. Ewes returning to service during autumn are an evidence of reliable estimates of conception rates. On the other hand, percentage of returns in the spring can not be relied upon for a true estimate. Difference in the percentages of lambing drop is apparently visible between autumn and spring. Salamon and Robinson (1962) observed that of the estimations done on the sum of returns to service, 92% of successful single insemination as compared to 71 % in the spring.

Number of inseminations

Question arises as to the number of inseminations necessary to settle the ewes in the same estrous (Table 7.4). Various workers have observed beneficial results and they claim an increase in conception rate from 4 to 10 per cent by doing two inseminations per estrous period. It is considered advisable to do second insemination on the day following first insemination of ewe still in estrous. Similar results have been

obtained by Osikowski, (1965) in Merino ewes at 24 hours interval following natural service.

Volume of semen and number of spermatozoa per insemination

Kunznetsov (1934) recommended that at least 50 million sperms per insemination are necessary for conception. Experience shows that dose as low as 0.1 ml of neat semen is satisfactory for higher conception rate (Sinclair, 1957; Keast and Morley, 1949). A volume of 0.05 to 0.2 ml is found satisfactory which is expected to contain 50 to 100 million sperms. A fairly good quality of ram semen should contain on an average about 150 million sperms per 0.05.ml.

Higher conception rates have been claimed in ewes by using neat semen as compared to the rates, where diluted semen is used (Mies Filho and De Almeida Ramos, 1955b). In general, it is observed that conception rate of about 55 to 60% can be claimed to a single insemination, if a dose of 0.5 to 1.5 x 108 spermatozoa in 0.05 to 0.1 ml of semen, diluted or undiluted, is used for cervical insemination.

Site of insemination

Dun, (1955) observed that the external appearance of the cervix varied a good deal and difficulties may be experienced in locating the opening to the cervix. Because of the peculiar structure of the cervix of the ewe, it isn't possible to deposit semen in uterus. It may be placed (i) in the opening to the cervix, (ii) on the cervix as it projects into the anterior end of the vagina or (iii) in the anterior end of the vagina.

Insemination

When the ewe is presented for insemination, the lips of the vulva should be cleaned with cotton wool soaked in normal saline. A speculum lubricated with white Vaseline or liquid paraffin is slipped into the vagina with a rotary motion and the cervix is located and imprisoned in the opening of the speculum. The semen is drawn into the insemination pipette and the tip of the insemination pipette is inserted gently into the opening of the cervix. About 0.1 ml of semen is deposited into the opening of the cervix and then the insemination pipette and the speculum are withdrawn.

Heterospermic inseminations

Favourable results have been claimed and higher conception rates obtained by use of pooled semen samples from different rams (Aslanjan and Camuha, 1950; Mamedjarv, 1952; Stojanovskaja and Mesjacev,

1957). However, similar results could not be reproduced in Australia (Dunn, 1956).

Detection of estrous in ewes

There are two ways of detection of estrous in ewes. One is by hand teasing in yards with a vasectomised ram. A loose piece of soft thick cloth is tied to the girth and kept hanging in front of preputial orifice, to avoid natural service. In the second method, vasectomised rams with breast painted with red clay (Geru under Indian conditions) are allowed to run free in the flock. The fluid paint is renewed daily. Ewes, which are marked with paint, are separated for insemination and next morning they are teased again to confirm if the heat is over or else a second insemination is done to those which are still in estrous.

Ewes remain in estrous for about 30 hours on an average. In exceptional cases, it may extend over 2-3 days (Table 7.8). The ovulation may vary considerably in relation to the onset of heat. Mckenzie and Terrill (1937) observed that ovulations in the ewes generally occur at the end of heat period. Insemination done before the end of heat period results in higher conception rates than those at or after the end of the heat period.

Anestrous ewes can be brought in heat by 1/M injections of progesterone for 10 days and PMSG 400 i.u. on the last day of progesterone injections (Antoine *et al.,* 1992).

Faulty techniques resulting in low fertility

Some obvious reseasons that lead to failures are:

1. Fear of not mustering ewes quickly enough so that they are kept in small paddocks and often underfed
2. Faulty mustering ewes in estrous missed and not presented till 24h too late
3. Failure to look after rams prior to the collection time
4. Too much time spent in drafting sheep
5. Failure to recognize vaginal mucus changes, thus leading to faulty testing
6. Faulty management of donor rams causing loss of libido
7. Faulty management of rams e.g. mixed age groups together leading to fighting, mounting and a wastage of semen
8. Bad handling and unnecessary handling of ewes after insemination.
9. Failure to have strong and fit teasers.

Table 7.8 Reproductive life of females

Attributes	Cow	Buffalo	Camel	Mare	Sheep	Goat	Sow	Bitch
Age at puberty (Months)	24-31	36—41	44-48	10-24	10-12	10-12	5-8	6-8
Age at maturity (Months)	28-35	37-42	45-49	30-36	12-15	8-15	8-12	12-18
Type of estrous cycle	Poly estrous	Poly estrous	Poly estrous	Seasonally poly estrous	Poly estrous	Poly estrous	Poly estrous	Monoestrous
Length of estrous cycle (days)	18-21	20-24	10-21	19-25	16—18	15-24	19-20	
Duration of estrous	10-24 h (16)	10-32h (30-36 h)	1-7 days (3-4 days)	2-11 days (6 days)	30-60 h (36-48 h)	30-60 h (36-48 h)	1-3 days (2 days)	4-13 days (7 days)
Time of ovulation	14h after onset of heat.	18-24h after onset of heat.	-	24-28h before end of heat.	12h after commence-ment of heat	Last day of heat	30-36h from the commen cement of heat.	24-36 h from the comme-ncement of heat.
Gestation period (days)	278-290 (284)	305-342 (310)	330-340 (406)	329-346 (336)	143-159 (148)	147-155 (148)	121-116 (114)	62
Proper time of insemination	Middle to the late of estrous	Later half of estrous.	-	every alternate day beginning second day of estrous.	18-24h after onset of estrous.	24-26h after onset of estrous.	12-30h after onset estrous	2-3 days after of onset of true estrous.
Breeding season	Though out year	Though out year	Nov.-Feb	Mar.-June	Though out the year except during May and June.	Though out the year except during May and June.	Though out the year	Aug-Sept Feb.-March

Failure in A.I. technique

1. Failure to control temperature of semen.
2. Failure to pick up and position cervix quickly. Glass speculum with a lip is used in order to position the cervix and get good lighting.
3. Using too much air in the syringe as an air pump. This blows the semen out of the cervix entirely.
4. Not withdrawing speculum before depositing the semen. If this is not done, a negative pressure is set up and the semen is withdrawn (at times completely from vagina).
5. Lack of speed.

Factors affecting reproduction traits

Thapan *et al.* (1970) analysed, 1,041 ewes records of Targhee breed for a period of 12 years from 1951 to 1962 and reported that ewe's age at lambing was found to be the significant factor affecting fertility. Sidwell and Miller (1971) studied reproductive performance of 1893 ewes bred from Hampshire, Columbia-Southdale, Targhee, Suffolk and Dorset breeds of sheep and their crosses. The effects associated with years, age of dam and breeds had highly significant effect on all the three measures of reproduction except years on prolificacy and age on fertility. Yakin (1973) reported that the effects of year and age of ewe were significant for prolificacy and overall reproduction in Turkish Merino ewes. Forrest and Bichard (1974) studied reproductive performance of a low land flock of ewes and found that fertility increased with age of ewe. No differences between rams on prolificacy of their mates were observed as revealed from analysis of over 170 ram mating groups consisting of ewes of more than one year.

Vesely and Peters (1974) from their study on Romnelet, Columbia, Suffolk and North Country Cheviot breeds of sheep and their two breed and three-breed crosses responded highly significant effect of age of ewe on fertility, prolificacy and overall reproduction. Year of lambing effect was also highly significant for fertility and overall reproduction but non-significant for prolificacy. Mating type was significant for fertility and highly significant for overall reproduction but non-significant for prolificacy. They (Vesely and Peters, 1981) further studied reproductive performance of 1598 matings in Romnelet, Columbia, Suffolk and North Country Cheviot breeds and their two breed crosses. Fertility was influenced significantly by year, age of ewe and mating type, fertility rates in crossbred ewes were higher than those in purebred ewes mated to rams of another breed. Also crossbred ewes mated to crossbred rams had fertility significantly higher than purebred ewes mated to rams of the same breed. The same phenomenon was also evident in prolificacy

of the ewes. The results in fertility and prolificacy had a major effect on overall reproduction.

Dickerson *et al.* (1975) examined the breed and age effects on fertility for 8,129 ewe matings in seven domestic breeds and two strains of crossbred origin. Breed differences in age-adjusted fertility were large within years but rather inconsistent among years. Prolificacy increased curvilinear with age of ewe, from 100 per cent at one year to 160 per cent at 6 years and back to 135 per cent at 9 years. Breed differences were non-significant for overall reproduction.

Shrestha *et al.* (1983) studied the effect of strain, season and age at breeding on fertility and fecundity on 2,776 ewe lambs of a synthetic sire strain, two synthetic dam strains and two control strains (Suffolk and Finnish Landrace breeds). There were significant differences among strains. Although period of breeding and season had an effect on reproductive traits, the strain differences were not consistent. Increased age had a significant and positive effect on the traits studied.

Faluny (1986) reported that season of mating was the most important factor affecting fertility in Romaney sheep. Only 42.5 per cent of the ewes exposed during the summer conceived compared to 100 per cent in the fall and winter. On other hand, year of mating and age of the ewe had little effect on this trait. Season of mating was also significant for prolificacy. Litter size at birth increased progressively with advance in parity.

Dangi *et al.* (1988) studied the differences in reproductive efficiency of 775 ewes joined in four purebreeds (Finnsheep, Dorset, Lincoln and Rambouillet) and their crosses. Breed group of lambs and age of dam both had highly significant effect on all the three reproduction traits except for breed on fertility. Year effect was signjficant for fertility and overall reproduction but not for prolificacy.

Rastogi *et al.* 1979 reported highly significant effect of age of ewe-year of lambing prolificacy and overall reproduction in Columbia, Suffolk and Targhee breeds of sheep. Non-significant differences were detected among the mating systems and among the three purebred mating groups for these traits. Three breed cross mating had significant effect on these traits while two breeds cross mating were non-significant.

Slana and Vyhanalek (1988) found significant differences due to breeds for fertility in their study on 2010 Czech Merino, Stavropol, Askanian, Caucasian and Gemlan Mutton Merino ewes.

Aboul-Naga *et al.* (1989) studied reproductive performance of pure Finn (F), Rahmani (R) and Ossimi (0) sheep, F_1 crosses (FR and 0), back crosses to R(RFR) and 0 (OFO) and crossbred sheep obtained by interbreeding (RFR) F_2 and (OFO)F_2. Fertility and prolificacy were

significantly higher in F_1 and backcross ewes than in local ewes. Seasonal variation in fertility differed among genotypes while all breeds showed marked seasonal variation in prolificacy.

Fahmy (1989) reported that prolificacy and overall reproduction were significantly affected by season of mating and parity in Romanov sheep. The most prolific mating were those of the autumn and of ewes in their fifth parity.

Kasseme *et al.* (1989) studied 3500 records of reproduction in Awassi sheep and reported that mean number of lambs born increased ($P<0.01$) with age of ewe up to 5 years, then declined at a slow rate. Fertility was, however, not significantly affected by age.

Boujenane and Bradford (1991) studied fertility and prolificacy of Sardi, D'man and their crosses in different combinations. Season and parity within group had a significant effect on both the traits. The mean performance levels tended to increase as the ewes became older.

Kleemann *et al.* (1991) reported significant effect of the year for all the three reproductive components in South Australian Merino and its crosses with Dorset.

Young and Dickerson (1991) observed that the effect of breed of ram was non-significant for fertility, prolificacy and overall reproduction in the mating of Booroola Merino and Finn sheep rams to Finn sheep and crossbred ewes.

Mohd Yusuff *et al.* (1992) analysed the records on Finn sheep, Rambouillet, Dorset and the their composite plus Suffolk, Targhee and a second composite for various measures of reproduction. Breed, year, age and season all had important effects on most ewe traits. The effects of age were large and strongly quadratic for prolificacy and overall reproduction and differed among breeds ($P<0.01$). Season of breeding also had major effect ($P<0.01$) on prolificacy that differed among breeds.

Urrutia *et al.* (1992) studied reproductive traits in Rambouillet ewes and reported that season of mating had highly significant effect on fertility, with ewes mated in spring having best performance and those in autumn or summer having the poorest performance.

Estrous during pregnancy

Estrous in the pregnant ewes is associated with follicular growth, but ovulation, breeding and conception may occur during an existing pregnancy, which would lead to superfoetation. Estrous has been observed in pregnant ewes (Matter, 1974; Younis and Afifi, 1979; Kandasamy and Pant, 1980; Sinha *et al.,* 1980, in first month of pregnancy. It is not usually accompanied by ovulation (Williams *et al. 1956*).

Gestation period

The duration of gestation in native and crossbred ewes has been reviewed extensively by Honmode (1970) and Kaushish (1971). The mean gestation length varies from 147to 153 days. The average gestation period varied from 151.2 to 152.2 days in Nali, Lohi and crosses of former with Mandia and Nellore (Kaushish and Arora, 1974a). Ramamurti (1963), Singh *et al.* (1977) and Kaushish *et al.* (1986) reported duration of gestation in Native, Nilgiri and Bikaneri and Soviet Merino, respectively.

The gestation period is shorter for exotic than indigenous ewes (Sahani and Pant, 1978), for ewes with exotic crossbred lambs, than those with indigenous lambs (Rao *et al.,* 1978), for lambs with lighter birth weights (Kishore *et al.,* 1980) and for female than male lambs (Narayanaswamy *et al.,* 1975). The gestation is positively related with weight at service (Kaushish, 1989).

The effect of breed, birth weight, sex of lamb, birth weight of dam at service, pH of amniotic fluid and post service gain in weight on gestation length has been studied by Ostgard (1957) and Kaushish and Arora, (1973, 1974 a). Gestation has been reported to have positive correlation with pH of amniotic fluid and negative with post service gain in weight and weight at service (Kaushish and Arora, 1974 a).

A study on post partum estrous interval has been carried out by Rawal *et al.* (1986b) to determine the effects of season and sex of lamb on this trait in Muzaffarnagri sheep. Following single normal lambing, twin lambing and abortions, gestation period averaged 137.4% 4.82; 168. b 23.63 and 172 and 13.22 days, respectively (Table 7.12). The sex of lamb did not have significant effect on postpartum estrous interval in case of single births. The effect of season was also non significant. One per cent ewes came in heat within 60 days. The average post partum estrous interval following twin lambing and after abortions was abnormally long 28.1 % ewes came in heat within 151-180 days after abortions.

Pregnancy diagnosis

There are several ways by which pregnancy can be diagnosed in sheep. Some methods are relatively simple. The failure of an ewe to return to estrous gives an indication that she is pregnant. Physical examination of ewes in late pregnancy is simple and quick. The lamb can be felt by gently palpating the ewes, abdomen. The udder becomes firm and enlarged in pregnant ewes A rectal probe can be used to palpate the uterus of ewe from about 70 days of pregnancy and is reliable when used by an experienced operator (Plant, 1980).

Table 7.9 Probable date of parturition when the females are served on the 1st or 16th day of the month in case the date of service is after these dates, add the number to parturition date given.

Parturition Calender

Date of service	Probable date of parturition						
	Cow	Buffalo	Sheep and Goat	Mare	Camel	Bitch	Cat
Jan. 1	Oct. 11	Nov. 7	May 31	Dec. 4	Feb. 11	Mar.4	Mar. 1
Jan. 16	Oct. 26	Nov. 22	June 15	Dec. 19	Feb. 26	Mar.19	Mar. 16
Feb. 1	Nov. 11	Dec. 7	June 1	Jan. 4	Mar. 14	Apr.4	Apr. 1
Feb. 16	Nov. 26	Dec. 23	July 16	Jan. 19	Mar. 29	Apr.19	Apr. 16
Mar. 1	Dec. 9	Jan. 5	July 29	Feb. 1	Apr. 11	May3	Apr. 29
Mar. 16	Dec. 24	Jan. 20	Aug. 13	Feb. 16	Apr. 26	May18	May 14
April 1	Jan. 9	Feb. 5	Aug. 29	Mar. 4	May 12	June3	May 30
April 16	Jan. 24	Feb. 20	Sept. 13	Mar. 19	May 27	June18	June 14
May 1	Feb. 8	Mar. 7	Sept. 28	Apr. 3	June 11	July3	June 29
May 16	Feb. 23	Mar. 22	Oct. 13	Apr. 18	June 26	July18	July 14
June 1	Mar. 11	Apr. 7	Oct. 29	May 4	July 12	Aug.3	July 30
June 16	Mar. 26	Apr. 22	Nov. 13	May 19	July 27	Aug.18	Aug. 14
July 1	Apr. 10	May 7	Nov. 29	June 3	Aug. 11	Sept.2	Aug. 29
July 16	Apr. 25	May 22	Dec. 13	June 18	Aug. 26	Sept.17	Sep. 13
Aug.1	May11	June7	Dec.29	July4	Sept.11	Oct.3	Sept.29
Aug.16	May26	June22	Jan.13	July19	Sept.26	Oct.18	Oct.14
Sept.1	June11	July8	Jan.29	Aug.4	Oct.12	Nov.3	Oct.30
Sept.16	June26	July23	Feb.13	Aug.19	Oct.27	Nov.18	Nov.14
Oct.1	July11	Aug.7	Feb.28	Sept.3	Nov.11	Qec.3	Nov.29
Oct.16	July26	Aug.22	Mar.15	Sept.18	Nov.26	Dec.18	Dec.14
Nov.1	Aug.11	Sept.7	Mar.31	Oct.4	Dec.12	Jan.3	Dec.30
Nov.16	Aug.26	Sept.22	Apr.15	Oct.19	Dec.27	Jan.18	Jan.14
Dec.1	Sept.10	Oct.7	Apr.30	Nov.3	Jan.11	Feb.2	Jan.29
Dec.16	Sept.25	Oct.22	May15	Nov.18	Jan.26	Feb.17	Feb.13

Richardson (1972) reviewed sophisticated methods of pregnancy diagnosis and she found over 80% accuracies by vaginal biopsy, ultrasonic foetal pulse detection and radiography. The foetal pulse detection is more practicable and is reviewed by Thwaites (1981) and Wani (1981). This method can accurately predict whether or not an ewe is pregnant if used after 60 days of pregnancy (Aswad *et al.,* 1976; Wani and Sahni, 1981) and the rate of lamb heart beat can be used to predict the date of lambing. Trapp and Slyter (1983) reported that ultrasonic scanning instruments developed to measure carcass fatness, when used

between days 69 and 112 of pregnancy, gave an accuracy of pregnancy diagnosis of about 90%. By laparotomy, pregnancy can be detected by as early as 30 days by skilled workers (Pacho, 1973).

If the date of breeding is known, an analysis of plasma progesterone, 17 days later will determine whether ewe is pregnant or not (Robertson and Sarda, 1971). For lactating ewes, progesterone levels in the fore milk can be used to diagnose pregnancy (Ayalon and Shemesh, 1979).

Parturition

The act of parturition is termed as lambing in sheep. Normal parturition consists of expulsion of normal viable foetus from the uterus through maternal passage by natural forces alone at a stage, when the lamb is capable of independent existence (Kaushish and Arora1974 b). It is difficult to predict the exact day of parturition in Nali sheep by studying the antepartum blood cholesterol content. (Kaushish and Arora, 1974 a).

Time of parturition

The time of parturition is one of the most critical periods in the life of an ewe. During this process, the ewe could possibly be injured and future reproduction efficiency be impaired temporarily or permanently. The distribution of births appears to vary with the breed of the ewe and the management system (Kaushish et. al., 1973; Younis and EI-Gaboory, 1978; Tomar, 1979; Bhaik and Kohli, 1980). Highest number of lambings took place between 3 and 6 AM and 3 and 6 PM (Kaushish *et al.,* 1973) in some native breeds and their crosses, whereas, maximum (40.0 per cent) lambing took place between mid night and 6 AM in Russian Merino ewes (Kaushish and Sahni, 1975) (Table 7.11).

Signs of parturition

The symptoms of the onset of parturition consist of changes in the birth canal, progressive extensibility to permit safe passage of foetus and hypertrophy of the mammary glands.

1. The vulval lips become resilient and oedematous, two to six times their normal size.
2. The ewes usually lay on the right side stretching the hind legs as far as possible, especially during contractions and frequently showed upward turning of lips.
3. Frequent grinding of teeth was also observed. About 6 to 8 h before the expulsion of foetus, the vulval labiae were about 0.5 cm apart and this distance increased to 1.0 cm about one hour before parturition.

4. The respiration rate increased about half an hour before the appearance of water bag (Kaushish and Arora, 1974 b).

Process of parturition in sheep

The process of parturition has been studied in detail by Tiwari *et al.* (1969a) and Kaushish (1971) (Table 7.10). The time taken for the completion of parturition was longest in Mandia x Nali and shortest in Lohi. The post service gain in weight of dam was negatively correlated with the time taken for the second and third stages of the parturition (Kaushish and Arora, 1974b) (Table 7.10). The duration of sequence of events in the second stage of parturition has also been studied in detail by them (Kaushish and Arora, 1974 a).

Table 7.10 Average (mean ±SE) duration of different stages of the process of parturition.

Genetic groups	Sex of the lamb	First stage (min)	Second stage (min)	Third stage (min)
Nail	M	343.5±19.50 (24)	33.6± 2.14 (27)	154.9±8.40 (29)
	F	396.0±14.37 (15)	33.8±2.04 (30)	135.5±14.69 (30)
	Both sexes	367.7±17.51 (39)	33.7±2.09 (57)	145.1 ±11.60 (59)
Lohi	M	259.0±38.07 (10)	33.1±1.61 (14)	131.7± 16.16 (14)
	F	421.3±28.41 (9)	32.3±1.81 (13)	131.6± 7.11 (12)
	Both sexes	288.5±33.25 (19)	32.8±1.73 (27)	131.6± 10.50 (26)
Nellore	M	327.8±29.11 (7)	33.8 ±0.80 (7)	161.4±13.17 (7)
x Nali	F	330.6±18.72 (8)	33.8±0.88 (10)	135.5±13.19 (10)
	Both sexes	329.3±24.41 (15)	33.8 ±0.88 (17)	146.1±13.18 (17)
Mandia	M	459.4 ±96.69 (9)	37.8 ±2.89 (9)	124.0 ±12.40 (8)
x Nali	F	468.6±74.4 (5)	41.8±5.81 (5)	113.7± 17.25 (4)
	Both sexes	462.7 ±83. 65 (14)	39.3±4.32 (14)	120.6 ±14.92(12)

NB: Figure in parenthesis indicate the number of observations

Relationship among weight of placenta, number of cotyledons and birth weight has been studied by Kaushish and Arora (1983). The average number of cotyledons varied from 66.6 to 74.1 between groups. The weight of placenta ranged from 0.195 to 0.259 kg. The sex of the lamb did not affect the placental weight and the number of cotyledons significantly. There was a positive relationship between placental weight,

Table 7.11 The per cent occurrence of births during different intervals in Russian Merino

Time Intervals*	Groups	Two year old			Three year old			Overall		
		Single	Twin	Combined	Single	Twin	Combined	Single	Twin	Combined
0.01-3.00	G-I	13.41	0.00	13.41	11.76	10.29	22.06	12.38	6.67	19.05
		(5)	(-)	(5)	(8)	(7)	(15)	(13)	(7)	(20)
3.01-6.00	G-2	24.34	2.70	27.04	8.82	8.82	17.65	14.29	6.67	20.50
		(9)	(1)	(10)	(6)	(6)	(12)	(15)	(7)	(22)
6.01-9.00	G-3	2.70	0.00	2.70	8.82	4.41	13.23	6.67	2.86	9.50
		(1)	(-)	(1)	(6)	(3)	(9)	(7)	(3)	(10)
9.01-12.00	G-4	10.81	0.00	10.81	1.48	2.98	4.41	4.77	1.90	6.67
		(4)	(-)	(4)	(1)	(2)	(3)	(5)	(2)	(7)
12.01-15.00	G-5	16.22	2.70	18.92	8.82	5.89	14.85	11.45	4.76	16.19
		(6)	(1)	(7)	(6)	(4)	(10)	(12)	(5)	(17)
15.01-18.00	G-6	18.92	0.00	18.92	2.98	4.41	7.42	8.57	2.86	12.38
		(7)	(-)	(7)	(2)	(3)	(5)	(9)	(3)	(12)
18.01-21.00	G-7	5.40	0.00	5.40	10.29	1.48	11.76	8.57	0.95	9.50
		(2)	(-)	(2)	(7)	(1)	(8)	(9)	(1)	(10)
21.01-24.00	G-8	2.70	0.00	2.70	8.82	0.00	8.82	6.67	0.00	6.67
		(1)	(-)	(1)	(6)	(-)	(6)	(7)	(-)	(7)

Figures in parenthesis denote the number of observations

***Zero hour starts from midnight**

Reproduction

number of cotyledons and birth weight (Kaushish, 1971). Weight of placenta as percentage of lamb weight generally centered round about 8.5 per cent in Nali, Lohi and the crosses of former with Mandia and Nellore (Kaushish and Arora, 1975). It was little lower in Bikaneri and Mandia (Tiwari *et al.,* 1969a). The effect of weight at service on time taken for expulsion of foetus and placenta has been studied by Kaushish and Arora (1973).

Post partum estrous

Most ewes are seasonal breeders; consequently there are few attempts for the ovaries to function until the breeding season occurs for that particular breed. In the breeds, which have been selected to produce two crops of lambs each year, there is need for breeding soon after lactation ceases. As soon as weaning occurs, these breeds usually show a cyclic activity in the ovaries accompanied by estrous and ovulation (Table 7.12).

Induction of parturition

Hormones like dexamethasone or flumethasone (Bose, 1972) can be used to induce lambing in sheep. Hormones have been used to combat prolonged pregnancy of Karakul ewes in South Africa (Roux and Wyk, 1977). The interval between injection and parturition depends on the stage of pregnancy (Aswad *et al.,* 1974) and if the ewes are injected too early, the lambs die (Webster and Haresign, 1981). There is a great scope for this in tropics.

Interlambing interval

It is the interval between two successive lambings. Normally, it varies between 7 and 12 months, but may be as long as 20 months also. Values in the literature of lambing interval give flock means of 218 days for Morada Nova sheep (Teixeira *et al.,* 1980) and 408 days for Mandya sheep (Purushotam, 1978).

Long inter lambing intervals may be due to long postpartum anoestrous period, failure to conceive, death of all embryos or abortion. Ewes, which do not conceive for two successive breeding seasons are culled under improved managemental conditions. Lambing interval decreases with parity up to 4, suggesting that young ewes which are still growing take longer to regain condition after lambing. Inter lambing period is also affected by season (Fall *et al.,* 1982).

Reducing age at puberty

Age at puberty, depends upon the nutrition of lamb. Some breeders

Table 7.12 Averages (Mean±S.E.) of post partum estrous interval following single normal lambing and abortions in Muzaffarnagari ewes.

Interval (days)	Single births		Abortions	
	Ewes (%)	Mean± S. E.	Ewes (%)	Mean ± S. E.
> 60	19.1	35.5±1.94	14.0	35.5±6.20
61-90	16.1	77.6± 1.18	5.3	77.0± 1.0
91-120	12.3	103.9±1.27	7.0	101.0±3.10
121-150	12.3	137.1±1.28	7.0	135.0±4.77
151-180	12.9	163.8±1.38	28.1	167.4±1.90
181-210	9.1	196.0±1.60	17.5	194.8±2.95
211-240	7.1	229.5±2.14	1.8	240.0± 0.00
241-270	2.3	254.1±2.70	7.0	249.8±3.11
271-300	3.9	285.2±2.20	5.3	272.7±1.53
301- and above	4.5	353.5:1: 7.03	7.0	426.7± 47.06

allow gimmers to mate immediately after they attain puberty. There is no evidence to suggest that early first lambing results in diminished reproductive capacity (Wilson and Durkin, 1983). The hormonal stimulation of lambs is of practical use in the tropics. The gonads of prepubertal sheep respond to exogenous hormones, but animals stimulated in this way do not commence spontaneous estrous cycle (Hunter, 1980).

Reducing inter lambing interval

An 8 month of lambing interval is possible provided that the nutrition and management are satisfactory (Naude and Grant, 1979). Hormonal treatment can be used to stimulate estrous, where, seasonal anestrous from photoperiod results (Fletcher *et al.,* 1980).

The period between lambing and conception (closed service period) of poorly fed ewes is about 180 days, if no hormonal treatment is given. Intensively fed West African Dwarf ewes conceive at an average of 43 days after lambing (Berger and Ginisty, 1980). Estrous can be induced by using intravaginal sponges as early as 17 days after lambing (Nie Kerk, 1979). Honmode *et al.,* 1971a) induced heat in local Malpura ewes by inserting sponges 30 days after lambing. Early postpartum breeding of sheep in Ghana reduced lambing interval to 6 months (Brown *et al.,* 1972). Sheep, loose weight, if bred frequently (Sahni and Tiwari, 1974b). A seasonal production on lambs results in high lamb mortality (Labban and Ghali, 1969) and poor growth rate (Ganesakale, 1975).

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8.

Embryo Technology

Heape (1890) was first to transfer eggs from the uterus of one Rabbit into another. Later on, other workers in transferring eggs in other domestic animals made similar efforts. The use of the technique was mostly limited to laboratories only during earlier stages, but now its use on commercial scale is being exploited.

Norminally, a sheep produced 6-7 lambs in whole of its life, but it can be increased several times in case of superior dams by the use of this technique. Many workers have done researches on embryo transplantation (Church and Shea, 1975; Hinkelman, 1979; Moore and Eppleston, 1979; Willardsen *et al.,* 1977; Dunn, 1980; Bradford and Kennedy, 1980) super ovulation (Honmode and Tiwari, 1968, 1973; Honmode *et al.,* 1971a; Elsdon *et al.,*1974; Wilmut and Sales, 1981) and embryo storage (Kardymowiez *et al.,* 1976; Willardsen *et al.,*1977; Patil and Bhosrekar, 1978; Smorag *et al.,*1978).

Increasing the lambing frequency beyond the traditional once a year crop, has been possible with use of appropriate reproductive technology, including hormonal treatment. It was possible to achieve two lambing every 13 months or 3 lambing every 24 months, lambing rate varying from 1.82 to 3.70 lambs per ewe per year in different countries. Integration of the various reproductive technological innovations into a single package of practice have been tried with the objective of producing lambing all the year round at intervals of 4 months. Hormonal induction of multiple lambing in flocks that show an inherently low twining percentage has been demonstrated to be practically successful even under commercial farming systems when the question of parental lamb mortality is adequately tackled through appropriate lamb management. More recently, the multiple lambing programme has been linked with estrous synchronisation, the set time A.I. and induced lambing for better economic management.

The ovulation rate can be increased if the ovaries are stimulated with exogenous gonadotrophins. Superovulation used in conjunction with embryo transplantation constitutes a method of accelerating and improving the reproductive performance of selected ewes. These

techniques have been of considerable interest to shepherds and persons concerned with improving reproduction.

Synchronization

The success of embryo transplantation depends upon the efficient heat detection in prospective embryo donors and recipients so that various operations are carried out on specific days. Vasectomised or aparoned rams can be used for heat detection. The use of progestagens and prostaglandins facilitate the planning of subsequent operations. Daily injections of progesterone in oil, progesterone impregnated intravaginal sponges or ear implants are all effective as are various other progesterone treatments (Lamond, 1964; Falkenberg *et al.,* 1964; Karihalo and Singh, 1967; Shelton and Moore, 1967; Honmode, 1969, 1971; Honmode *et al.,* 1971 b).

The most commonly used method of estrous synchronisation in sheep is a vaginal sponge, impregnated with progestagen, withdrawal a single dose of PMSG is given (Britt, 1979; Combellas *et al.,* 1980). Using sub-cutaneous implants gives similar results although the interval from removal of progestagen to estrous and duration of estrous are both shorter with implants than sponges (Faure *et al.,* 1980). It is also possible by daily injections of progesterone (Dhanda and Arora, 1977) and by feeding melengestrol acetate (Tripathi, 1977). Synchronisation can be done more conveniently by giving two injections of prostaglandin at an interval of 10-12 days (Haresign, 1973). The schedule of giving two injections gives better results than that of giving single injection. Age, breed, season and time during estrous cycle affect the response to a particular treatment. PMSG has been used most extensively in super ovulation. Relatively small proportion of follicles present in the ovaries is responsive to PMSG (Hay and Moore, 1978). The dose of the PMSG should be adjusted in such a way that it does not cause ovulation of immature follicles. In most cases a dose of 20-25 i.u. of PMSG per kg, body weight has been used.

PMSG can also be used in conjunction with progestagens (Moore, 1970). Progestagen priming is necessary if anestrous ewes are to be used as donors (Lamond, 1964) and is also essential if prepuberal ewes are to be superovulated (Trounson and Willadsen, 1977). The sheep should be kept on progestagen for at least ten days and injected with PMSG about 3 days prior to planned onset of estrous. Any of the following methods can be used for super ovulating ewes:

Synchronization with subcutaneous (S/C) progesterone implants (350 mg progesterone, Abbot labs) for 10 lays or two intra muscular (I/M) injections of 125 mg Cloprostenol (Estrumate ICI Ltd.) 10-12

days apart. Almost all ewes come in heat 24-48 h following progesterone withdrawal or second injection of $PGF_2 \mu$ on day 11-12 of the following cycle an I/M injection of 1250 i.u. PMSG (Folligon, intervet labs). 48 h later an I/M injection of 125 mg Cloprostenol after which the ewes are penned without access to food and water and checked regularly for onset of estrous. The majority of the ewes come in heat 24 h later practically all by 36 h.

Super ovulation

Factors controlling early embryo development are poorly understood and consequently the ability to culture embryos *in vitro* is limited. Oviduct specific glycoproteins have been reported in several species including the sheep (Sutton *et al.,* 1984; Gandolfi *et al.,* 1989). These proteins, together with those from serum strangulates, are thought to contribute towards the establishment of an unique oviductal environment. It was found by Walker *et al.,* (1988) that about 90% of the sheep embryos cultured for 3 days from the zygote stage developed to Day 14 of pregnancy in synthetic oviduct fluid medium (SOFM7) supplemented with heat inactivated human serum.

The ovaries may be stimulated with exogenous gonadotrophins to increase ovulation rate (Hunt *et al.,* 1971). Various workers (Pandey *et al.,* 1972; Sengupta *et al.,* 1978) have attempted super ovulation with variable degree of success in India. The lambs born in multiple births have less chances of survival than those born in single births (Seth *et al.,* 1972). Sharma *et al.* (1992) observed increase in the number of corpus luteum with the increase of age and body weight of dam 6 days post estrous in super ovulated sheep.

Breeding

If natural service is done, it should be done on several occasions during heat, but failure of fertilization occurs in super ovulated ewes. The failure is due to decreased transportation of sperms, through the cervix. Fertilization rate can be increased by doing insemination in the uterus of super ovulated ewes (Killeen and Moore, 1971; Trounson and Moore, 1974). The effect of PMSG on the lambing performance has, also been studied (Sengupta *et al.,* 1976).

Collection of embryos

Eggs are normally collected when they enter the fallopian tubes. The collection of fertilised ova is done 2,3, 4 and 6 days after fertilization in case of sheep, cow and pig and mare, respectively. Normally 40-80 per cent fertilized eggs can be recovered by surgical means. Surgical method

of embryo collection has been adopted in laboratory (Daniel, 1971) and domestic animals (Dzillk, 1971; Murray, 1978). Fertilized egg moves to uterus from fallopian tubes in 3 to 4 days. The number of embryos collected from fallopian tubes exceeds those collected from the uterus, but the embryos collected from the latter are more viable (Newcomb and Rowson, 1975) and can be frozen more successfully. Use of medium 199 is more popular for the embryo collection (Rowson *et al.,* 1969). Different mediums used for embryo collection are given in Table 8.1. Streptomycin and penicillin are mixed at the rate of 50 mg and 1 lakh i.u. per litre. Bovine Serum Albumen must be added to this medium @ 0.3 to 1.0 per cent. The pH of the medium is kept between 7 and 8 but a pH between 7.2 and 7.6 gives best results. Double distilled water should be used for making the medium. Detailed information has been given by Gwatkin, (1972) for making medium.

Collection of eggs from super ovulated ewes within first few hours of ovulation results in low recovery rates. The best results are obtained if no tube is inserted into oviduct. For collecting embryos on day 12, 13 and 14, a curved large bore glass tube is inserted into the uterine horn and 15-20 ml of medium is flushed from the tube of the uterine horn or from the oviduct to be collected in a glass cup. The incision is closed with an absorbable suture. Premature ovulation and embryo collection in ewes has also been tried by Heard and Walker (1992) Different media used for embryo collection are given in Table 8.1.

Embryo transfer

Embryo transfer has been reviewed extensively by Trounson and Rowson (1976) and Willardson and Polge (1980). It allows for rapid multiplication of valuable genotypes. This technique does not have a high rate of success in sheep (Armstrong and Evans, 1983) although it has been used to multiply wool producing genotypes in India (Zanwar, 1981).

The embryo to be transferred is picked up with a pasture pipette in 0.04 ml of medium. The tip of the pipette is inserted 2-3 cm into the uterine lumen through the wall from uterotubal junction and the fluid containing embryo gently expelled.

Sheep embryos for transplantation may be collected from a few hours after ovulation up to 14 h after onset of estrous. In ewes which are mated naturally, collection rate may be as high as 75% of the eggs ovulated. Maximum egg recovery rates are obtained if collections are made while the eggs are still in the oviduct. A ewe may be used as a donor several times provided sufficient time is allowed for the establishment of normal cycle (Jainudeen and Hafez, 1974).

Table 8.1. Mediums used for embryo collection

Quantity in mg/L	Improved Delbeco (Gwatkin 1972)	Hemice mixture GIBCO	Improved fallopian tube fluid (Tervit *et. al.* 1972)	Tissue culture medium 199 GIBCO	Vitan medium (Gwatkin. 1972)
Sodium chloride	8,000	7,400	6,300	8,000	5,140
Potassium chloride	200	285	533	400	350
Calcium chloride	100	33	190	140	-
Magnesium chloride	100	-	100	-	-
Magnesium sulphate	-	153	-	200	294
Sodium bicarbonate	-	1,200	2,106	350	1,900
Disodium Phosphate	1,150	154	-	48	-
Potassium dihydrogen phosphate	200	83	162	60	162
Glucose	1,000	1,100	270	1,000	1,000
Sodium Pyruvate	36	110	36	-	36
Sodium lactate	-	-	370	-	2,416
Calcium lactate	-	-	-	-	527
Ribose	-	-	-	0.5	-
Deoxiribose	-	-	-	0.5	-
Vitamins	-	Yes	-	Yes	-
Nucliec acid	-	Yes	-	Yes	-
Trace elements	-	Yes	-	Yes	-
Bovine Serum Albumen	-	-	-	-	3,000
Cholesterol	-	-	-	0.2	-
Sodium acetate	-	-	-	50	-
Lipoic acid	-	0.2	-	-	-
Tween 20	-	-	-	-	-
Glucothion	-	-	-	0.5	-
Vitamin E	-	-	-	0.01	-

Care at embryo transplantation

Developmental stages ranging between one cell and elongated gastrula (day 14) have been successfully transferred in sheep. If the main interest to maximize the number of lambs produced, embryos ranging between eight cells (day 3-4) and early blastocysts (day 7) are most convenient to work with. The embryonic survival rates have varied, but under optimal conditions some 60% or more of the embryos transferred can be expected to give rise to lambs (Moore and Shelton, 1964 a,b; Rowson and Moor, 1966; Moore and Trounson, 1977). Differences with respect to breed between donor and recipient are of no consequence as long as the recipient is sufficiently large to carry and give birth to the type of lamb produced (Hunter *et al.,* 1955; Lowson and Rowson, 1972). Healthy, mature ewes, which have previously lambed, should be chosen as recipients.

In the planning of embryo transplantations, one should aim at precise synchrony of estrous in donor and recipient. Although acceptable pregnancy rates are still obtainable if there is an asynchrony of t: 1 or even t: 2 days (Rowson and Moor, 1966), the best results are probably obtained when donor and recipient are at precisely the same stage of the estrous cycle, (Moore and Shelton, 1964b). Recipients that came into estrus slightly later than the donor are preferable to recipients that came into oestrus earlier. Day 13 and day 14 embryos should be transferred to day 12 recipients, since luteal regression is initiated about day 13 in the nonpregnant ewe (Rowson and Moore, 1966). Ideally, the developmental stage of the individual embryo, rather than the stage of estrous cycle of the donor should govern the choice of recipient, e.g. a morule of some 30 cells should preferably be transferred to a day 5 or 6 recipient even if it was collected from a day 7 donor. Similarly, the stage of development rather than the age of the embryo should decide the choice of recipient for an embryo, which has been cultured or stored *in vitro.*

If two embryos are to be transferred per recipient one should be transferred to each side of the genital tract; a single embryo should be transferred to the side ipsilateral to the ovary carrying the corpus luteum. The overall embryonic survival rate is about the same whether one or two embryos are transferred per recipient. Embryos less advanced than eight cells should be transferred to the oviduct, and more advanced embryos to the uterus.

One cannot escape the conclusion that although relatively efficient methods of superovulation and embryo transplantation have been developed in the sheep, the practical application of these techniques would only be economically feasible in exceptional circumstances. It is

equally evident that they are potentially extremely valuable to investigators of basic mechanisms and relationships in reproductive physiology, genetics and developmental biology.

Embryo storage

For practical use in egg transfer experiments, it is desirable to maintain the egg *in vitro* in a more or less dormant state for various periods of time allowing accurate synchronization of egg development. Storage of eggs also makes possible long distance transportation of embryos (Chang and Marden, 1954; Adams, 1961; Hunter *et al.,* 1955). Storage of embryo is needed between collection and its transplantation. Normally embryo can be stored at 3°C up to 24 hours. Embryo mortality rate increases if it is transplanted after 24 hours (Davis and Day, 1978). The storage of the embryo, at four cell stage is easier in sheep (Tervit and Glood, 1978). Embryo can be stored between 15 to 25°C from few hours to one day, but it can be stored for some days between 0 and l0°C (Boland *et al.,* 1978).

Cryopreservation of embryos

Cryopreservation harms the embryos. If dimethyl sulphoxide is added to the medium, the freezing occurs much below zero degree Celsius. The embryo is rapidly cooled up to °C, after that the temperature is lowered up to 7 °C at the rate of one degree per minute. Thereafter, temperature is lowered @ O.3°C per minute up to –33°C, then the embryo is lowered in liquid nitrogen.

Difficulties experienced in super ovulation

Effect of nutrition on embryo has been studied by Dunn (1980). Factors affecting super ovulation have been studied in detail by Armstrong and Evans (1983). Some of them are:-

1. Response varies from animal to animal.
2. Eggs pass rapidly through the fallopian tubes.
3. Repeated collection of eggs damages egg producing ability of the sheep.
4. If this method is followed in young sheep the fertility of the eggs is reduced.
5. Sometimes the ova instead of entering the fallopian tubes enter the abdominal cavity.
6. Age and plane of nutrition affects it.
7. It also depends upon the number of times collection has been done earlier.

In vitro fertilization and embryo transfer

Mammalian eggs can be fertilized *in vitro* by a relatively simple culture technique. Ovulated eggs or oocytes- matured *in vitro* or oocytes collected from the ovary just before ovulation could be used for fertilization *in vitro*.

Eggs are incubated with capacitated spermatozoa in a suitable culture medium for 2-5 h. Capacitated spermatozoa could be obtained either from female reproductive tract after artificial insemination or spermatozoa capacitated *in vitro* could be used. For *in vitro* capacitation of spermatozoa, sperms are incubated in a medium containing tubal fluid, follicular fluid or heat treated serum for 2-6 h, depending upon the species. A drop of capacitated spermatozoa is then mixed with eggs under paraffin oil, which was previously equilibrated with the same medium. The petri dish is incubated in a humidified atmosphere containing 95% air and 5% CO_2. After 2-5 h the eggs are recovered, washed with fresh medium and cultured for a further period of 3-5 days. The eggs are transferred to recipient females when they are at the stage of morula or early blastocyst. Only females with their reproductive cycle synchronised with the age of the embryo can successfully accept the embryo.

9.

Biotechnology for Small Ruminants Production

Ruminants convert the vegetable matters into meat, milk, wool, etc. However, rations used for intensive mutton, chevon, and beef production are largely based upon grains, which can also be consumed by mankind. This has resulted into a competition between man and animals. The conversion efficiency of crude protein and energy into animal product is very poor. Any application of biotechnology to enhance the small ruminants production should have the priority in increasing conversion efficiency of dietary components into animal products. In the processing of small ruminant producucts such as meat, milk cheese and wool etc., the application of genetic engineering to micro-organisms used in food fermentation could improve fermentation efficiency, flavor, texture, nutritive value or appearance of the final producer and shelf life and also removing the antagonistic compounds and pathogenic microbes. In wool processing, the problems related to bur and grease can find a solution in a microbe capable of fermenting them.

In animal reproduction the technique of biotechnology technique includes sexing by measuring the DNA contents to differentiate X and Y chromosome bearing sperms the recovery and transfer to gametes embryos, their cryopreservation for future use, their production of better animals than the best available. The important biotechnology applications during the growth of small ruminants include the genetic restructuring of rumen microbes for better utilization of feed resources, improving animal health through monoclonal antibodies and the membrane research for the treatment of gastrointestinal illnesses.

Genetic engineering

The first step of genetic engineering is to break open the cells of an organism that has a desired function and isolate the DNA, which contains the genes determining the function. Then the DNA is cut into

smaller pieces with commercial enzymes which act at specific regions and the fragment are sliced into specific DNA molecules that carry the DNA to living cells. These cloning vectors are either small plasmids of viruses that are capable of being such transcribed and replicated. Plasmids have been isolated from some predominant species of ruminal bacteria such as *Butyrivibrio fibrisolvnts. Bacteroides ruminicola, Ruminococeus albus, R. flavefaceints, Salenomonas ruminantium*. The transfer can occur via transformation conjugation and transduction.

Conjugation: Conjugation entails the close physical contact of two bacteria (some times via sex pili) and a plasmand mediated transfer of DNA from the plasand containing 'male' bacterium to the plasand lacking 'female' bacterium. In Escherichia coli every females bacterium is converted to a male bacterium by conjugation, but the inheritance of fertility factor, if, is not well understood on other bacteria. However, because ruminal bacteria are known to contain antibiotic resistance plasmids conjugation is at present the most workable system for transferring genes between rumen bacteria.

Probing the genes: Because each cell contains thousand of different genes, finding one gene is very difficult. Identification is made easy by radioactive probes that are complementary to desired genes because the probe is radioactive the specific gene can be recognized on X-ray film. Probe can be synthesized if we know a sequence of at least five amino acids in the gene product. More than five amino acid are needed if leucine, serine or arginine is present. The code is less degenerate for other amino acids.

Transformation: Some bacterial are able to intake up free DNA through their cell wall via processes known as transformation. The transformation work well in enteric bacteria and bacilli. Some bacteria including intestinal bacteroides are easily transformed. In the rumen bacteria face the shortage of carbohydrates and they rapidly degrade nucleic acids to obtain sugars. Therefore, ruminal fluid has high extra cellular nucleases activity. Due to the facts, it is unlikely that process of transformation would occur in rumen.

Transduciton: In transduction, infection of specific of bacteria by viruses (phage) entails the transfer of viral genome to the host. Some of the recipient cells survive the infection and these survivors contain genetic material that was derived from cells in which the virus had grown. Today, it is possible to purchase lambda phage and ligate small piece of DNA in thorn. Lambda phages readily infect *E. coli* because not many lambda phages are known for infection to most of the predominant

rumen bacteria transduction has limited application for direct manipulation involving rumen bacteria. Although, recently it has been shown that rumen contains phages of 26 types of three viral families, their application in genetic engineering is yet to be tested. However, transduction into *E. coli* is an effective method of screening for specific genes and amplifying them.

Manipulation of rumen bacteria

Rumen has slightly acidic pH, strict anaerobic conditions (Redox potential $E_0 = -0.35V$) and has immense population (10^{10} cells/ml) of diverse microbes. The rumen microbes provide animals with short chain volatile fatty acids and microbial protein through fermentation of cellulose and other organic matter. During rumen fermentation Methane, heat and ammonia are also evolved and these products present a loss of either energy or protein to the animals. Methanogenesis itself causes about 11% loss of energy. Therefore, successful attempts to modify the rumen ecosystem by genetic or other treatments must enhance the beneficial aspect of rumen fermentation while minimizing the fermentation losses.

Rumen microbes are a source of proteins for ruminants and they can provide as much as 90% of the amino acids reaching the small intestine. Therefore, yield of microorganism (microbes per g organic matter fermented) is very important. Rumen microbes degrade dietary proteins and generated amino acids can act as sources for microbial protein synthesis or be fermented as energy source. Presentation of fermentation of amino acids as energy source should receive adequate attention. Because amino acid fermentation is coupled with methane production, methane inhibitors should have protein-sparing effect.

Reduction in the efficiency of feed utilization in the rumen is due to the non-specific lysis of bacteria within the rumen and subsequent fermentation of the bacterial protoplasm. Large numbers of bacteriophages present (up to 10^{11}/ml. of fluid) in the rumen are implicated in the lysis are obligated pathogens of bacteria and occurs in dense populations in the rumen.

Microbial present in rumen may have pronounced effects upon all the ingested materials including toxic and anti nutritional compounds. They also protect the animals from toxic substances like mimosine and oxalates. Tryptophan is converted into 3 methylindole, which causes respiratory disturbance in cattle. Tannins, lignins and phenolics inhibit the fermentation and also have bacteriostatic and bactericidal effects.

In the light of above, an ideal rumen can be visualized to have following properties, promotes high rate of fiber digestion, provides

rapid and efficient production non microbial protein should have reduces viral activity, should be devoid of protozoa, minimize the loss of feed energy by methanogenesis, should have low rate of protein fermentation and only minimal accumulation of ammonia and anti nutritional factor and usefully ferment them. Most genetic engineering problems involve plasmids and which can be lost of the palsmid transcription, provides no benefit to the organism. To site an example, genetically engineered bacteria for tannin dissimulation are grown in a medium devoid of tannis, there is possibility that bacteria may loose its ability to utilize tannis. Antibiotic resistant genes are often added to the plasmid to increase its stability. It will be worthwhile to note that erythromycin resistant Bacteroides ruminicola, when transferred more than three times in the batch cultures lacking antibiotic was found to have very small number of antibiotic resistant cells. This raises a question about the use of antibiotic resistant plasmid in rumen microbes, as it will not be practicable to have a definite concentration of antibiotic in the rumen. Stability might be increase if recombinant genes were incorporated into the chromosomes. While chromosomal changes are possible the process of obtaining functional additions is much more complicated.

Considerable research is necessary to develop techniques to examine the ecological niche of the genetically improved rumen microbes, their survivability, their growth and maintenance in the rumen. Isotope technology coupled with genetic engineering must be put into action to solve the problem for this N, S or C labeling of bacteria can be done both *in vivo* and *in vitro.* To follow the dilution in the rumen individual microbes will have to be identified in rumen populations. This may be achieved by developing DNA hybridization probes for individual species. However, when these facilities are not available the animal performance can give a good reasonable indication. Once the growth turnover and survivability of genetically altered rumen microbe is tested under farm conditions, the technology may be adapted to the conditions of farmers and then transferred.

Under traditional sheep farming system low lamb output per ewe per year is a major factor limiting the energetic efficiency of sheep production. Over the past 50 years reproductive physiologists all over the world have tried to evolve total management package, including reproductive management to realize the full reproductive potential of the species commensurate with the potential biological ceiling of litter production and an economic lambing interval. To achieve this goal, the new reproductive biotechnological innovations have been successfully used so much so that these techniques are being presently used in several countries on a commercial scale.

The reproductive innovations for advancing sheep breeding season, more frequent lambing, induction of multiple births, synchronised breeding with fixed time artificial insemination, controlled and compact lambing are now practical realities. The possibility of embryo technology in sheep has been clearly demonstrated. Through hormonal manipulations and appropriate strategic breeding of ewes and lambs at 7 to 8 months of age is now a distinct possibility.

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10.
Wool

Unlike other ruminating animals, wool continues to grow in case of sheep. The sheep are shorn twice or thrice in a year. Some southern breeds like Nellore, Mandya and Tenguri are hairy. The wool fibre is tensile and hygroscopic in nature. It does not catch fire so easily. Good quality wool fibres are thin, soft and fine thread can be prepared from these. They can absorb colour very well. The hairs are not that tensile and cannot take colour so easily.

Normally the fibre diameter of wool varies from 12-70m. The fibre diameter of superior wool varies from 15-25 m. The wool produced from Rambouillet and Merino sheep is of this quality. The number of crimps is more in the wool. The fibre diameter of native wool varies from 30-70m.

Fibre length, number of crimps and diameter plays important role in the determination of wool quality. The fineness of the fibre is known by the number given after making thread. Bundles are made of 256 yard long thread from ordinary wool or 560 yards long from combed wool. The number of such bundles per pound is known as count. If 10 such bundles weigh one pound, the count of such wool is ten. The merino wool is of 60-70's count.

The history of wool dates back to the onset of civilization and references can be found in the Vedas the Old Testament the Bible and Greek Mythology. The Phoenicians were the early people who used woollen cloth. The dawn of twentieth century exhibited phenomenal increase in the production and use of woollen goods. Merino breed of Spain is spread to other European countries. The remarkable development in sheep breeding took place in Australia. As regards India, the earliest mention can be found in the Rig Veda as hymns were sung in praise of God Pasham meaning the Lord of the Shepherd. Even before the advent of British Raj India was famous for the Kashmiri woollen products such as Pashmina Shawls, etc. systematic development in sheep breeding and wool production started only after the attainment of independence.

Wool Production

The wool production from 1951 to 1992-93 had shown a continuous increasing trend, rising from 27.5 m kg to about 43.2 m kg with an annual increase of about 1.47 per cent as compared to the sheep population figure for the contemporary period or 0.55 per cent which would reflect that the wool production per animal has increased. This increased gain is reflected in crossbred sheep involving indigenous woolly breeds with exotic fine wool sheep breeds produced extensively in the state of Jammu and Kashmir and to a limited extent, in Himachal Pradesh and hilly regions of Uttar Pradesh. Major increase in wool production is in Uttar Pradesh followed by Jammu and Kashmir, Karnataka, Gujarat and Rajasthan. The wool production and quality in different regions of the country and state wise wool production data are presented in Table 10.1 and 10.2, respectively. The north-western region having 42% of the total sheep population contributes about 65% of the total wool produced in the country. The average wool production per sheep in India is only 0.9 kg as against the world average of 2.4 kg. Presently about 50 m kg of wools (both appeared and carpet types) are being imported to meet the requirement of the industry.

Morphological characteristics

As in the case of hair, wool also grows from the follicles in the skin of the sheep. Even though wool and hair seem to be similar products, there is considerable difference between the two. While wool is a thick and fibrous coat of sheep, hair is obtained from the coat of other mammals. While animal hair has a tendency to shed after obtaining maximum growth continuously. As a rule, wool is softer and finer than hairs of other animals.

Wool and hair fibres from core outwards consist of three layers viz. medulla, cortex and epidermis. Medulla is the inner most core of the non pliable follow celled structures containing pigment matter, which contributes for fibre colour. Cortex is the next layer comprising of many tightly packed and elongated cells that contributes for its strength and elasticity. Epidermis or cuticle is the last layer comprising of very thin and flattened cells or scales. The fibre or wool is more or less homogenous because cortex extends to the centre and medulla is almost absent. The irregularity of cuticle gives wool fibre a saw like or serrated appearance, which is attributable to its felting property.

Wool depending on the fineness and length of fibre can be classified into five categories viz., fine, medium, long, crossbred and carpet wool.

Fine wool: This is the best variety of wool obtained from Merino breed

of sheep, which originated in Spain. With the passage of time, its breeding however spread all around the globe and presently each and every country is having its own version. The famous ones are Australian Merino, Spanish Rambouillet, Russian Merino, etc.

Medium wool: This type of wool is obtained from breed such as Southdown, Shropshire, Hampshire, Dorset, Oxford, etc. most of these breeds are reared mainly for mutton and this type of wool is medium and somewhat coarser than wool obtained from cross bred sheep.

Long wool: Sheep breeds like LincoIn, Cotswold, Leicester and Romney Marsh produce long wool. These breeds are reared primarily for mutton. The staple length from 12 to 35 cm and it is coarser than the medium type of wool.

Cross bred wool: Wool produced by cross bred sheep is called cross bred wool. This type of wool is obtained by crossing higher yielding breeds like Merino or Rambouillet with long wool breeds like Polwarth, Corriedale, Hisar Dale etc., the type of wool produced is finer as compared to the medium type wool.

Carpet wool: This type of wool has good resilience property, which makes it suitable for the manufacture of carpets, blankets and druggets. It is nevertheless, significant to mention here that some superior qualities of carpet wool for producing tweeds, over coating hosiery etc. Primarily the undeveloped sheep in Asia produces it while Argentina and the Soviet Commonwealth also produce similar wool in large quantities. Most of the wool produced in India is carpet wool. Some of the breeds producing this type of wool are reared for meat as they produce rough hairy wool.

Chemical composition of wool

Wool is made up of protein, sterols and fats. It has 99 per cent fat and one per cent other materials. Wool has about 50 per cent, keratin, 8 percent carbon, 16.5 per cent hydrogen, 3.5 per cent nitrogen and sulphur and oxygen together constitutes 22 per cent.

Physical properties of wool

The quality of the wool is known from its thinness. It is expressed as counts. Normally thick wool fibres are longer. The length of fine wool, medium wool and coarse wool fibres is 4-12, 6-17 and 10-30cm, respectively. The number of crimps is less in coarse wool and more in

the fine wool. The friction decreases if fingers are moved from the root to tip of the wool fibre. It increases if the fingers are moved in reverse direction. Wool fibres can absorb more water as compared to other fibres. It can absorb water up to one third of its weight.

Chemical properties of wool

It dissolves in acid and alkali solutions. Acids break peptide chain bonds. Caustic soda solution dissolves wool fibre. Most oxidizing agents are used for decolourisation of fibre and preventing it from shrinkage. Wool becomes yellow if kept in warm humid places. It starts changing colour at 100 °C. Wool contains sulphur in significant amounts. The sulphur content varies among different sources but also varies along the fibre, the tips exposed to light and air containing less than the middle and root fractions. Most of this sulphur is in the form of cystine.

Sulphur occurs in considerable amount in plants and animals as a constituent of sulphur containing amino acids and other sulphur compounds. It is considered essential for both plants and animals. Although the sulphur content of wool is high and that of the foodstuffs low, this meager amount is sufficient to sustain quantity that affects quality of wool so that it is only rarely, that deficiency of sulphur alone occuRs The amount of nitrogen in wool is more or less constant, while the sulphur content shows a wider range.

Various researches have shown that ruminants on sulphur deficient diets may suffer from loss of appetite, poor wool growth, weight loss, eye troubles, weakness, negative nitrogen balance, reduced milk yield and eventually economical loss in production. The high protein feedstuffs and roughages are usually good sources of sulphur. Its adequacy in high grain urea rations has been questioned. In high plane of nutrition the wool yield was 25 per cent in comparison to low plane of nutrition. Low feeding reduced wool yield and it was the cause of high mortality in lambs. The high level of feeding also increased the fibre length.

Chemical structure and composition are most important parts of the wool fibre, because upon these depend the development of the fibre in regards to its treatment in many parts of the process of manufacture and more especially in regard to its relation to the dyeing of the yarn and goods.

Fibres which owe their origin to animals, such as, wool, hair and silk, have as their basis a series of substances which are called generally nitrogenous albuminoids. Of which casein, albumin, gluten and gelatin may be taken as leading examples. They are also called protein compounds. Recent studies have also found that wool contains phosphorus and the other essential elements of mineral matteRs Wool also contains five elements, namely carbon, hydrogen, oxygen, nitrogen and phosphorus.

Table 10.1. Mean values of wool parameters of some sheep breeds.

Breed	Half yearly wool yield (kg)	Fibre diameter (m)	Medullation percentage	Staple length (cm)	Remarks	References
Arabi	1.81	26.2	10.9	11.4	Annual clip	Ashmawyand Al-Azawi, 1982 a,b
Barki	-	33.9	14.0	9.8	Annua clip	Guirgis, 1973
Barki	1.90	-	-	-	Annual clip	Marai, 1975
Barki	0.93	-	-	-	Annual clip	Aboul-Naga, 1977
Barki	3.51	13.4	-	-	Annual clip	El-Oksh *et al.,* 1979
Bellary	0.33	59.0	43.4	-		Nagarcenkar and Bohra, 1983
Bellary	1.23	50.0	43.4	-	Annual clip	Acharya, 1978
Chhota nagpuri	0.18	51.5	83.6	-		Nagarcenkar and Bohra, 1983
Chokla	0.94	29.8	23.0	6.5		Arora *et al.,* 1975 b
Chokla	1.20	26.9	18.0	4.8		Mahajan *et al.,* 1980ab
Chokla	-	23.9	12.5	4.2		Pant *et al.,* 1980
Coimbatore	0.41	-	-	-		Mishra and Singh, 1979
Coimbatore	0.37	41.1	58.2	5.8		Nagarcenkar and Bohra, 1983
Coimbatore	0.27	393	66.0	6.9		Singh and Rathore, 1987
Corriedale × Coimbatore 50%	1.14	-	-	-	Annual clip	Mishra and Singh, 1979
Corriedale × Coimbatore 50%	0.39	29.4	28.0	6.1		Singh and Rathore, 1987
Corriedale × Coimbatore 50%	0.47	27.8	22.3	4.5		Singh and Rathore, 1987

contd.

Table 10.1. Contd.

Breed	Half yearly wool yield (kg)	Fibre diameter (m)	Medullation percentage	Staple length (cm)	Remarks	References
Corriedale × Coimbatore 50%	0.48	25.2	13.7	4.6		Singh and Rathore, 1987
Deccani	-	35.1	35.1	5.9		Daflapurkar *et al.,* 1979
Deccani	-	38.8	65.5	8.0		Ghanekar, 1983.
Deccani	0.74	34.9	42.2	7.0		Acharya. 1978.
Deccani	0.36	52.4	73.8	8.2		Nagarcenkar and Bohra, 1983
Deccani	0.74	37.4	34.1	6.9	Annual clip	Ghanekar, 1983
Deccani	0.34	-	-	-		AICRP on sheep, *Ann. Rept.* 1984
Deccani	-	15.8	36.6	4.6		Deshpande, 1987
Deccani	0.39	43.2	-	6.6		Charyulu, 1988
Corriedale x Deccani	-	14.5	28.8	5.2		Deshpande and Sakhre, 1987
Mandya x Deccani Deccani	-	19.3	40.9	8.3		Deshpande and Sakhre, 1987
Dorset x Deccani	0.66	30.9	-	8.4		Charyulu, 1988
Doreset x Deccani	0.51	-	-	-		AICRP on sheep, *Annual Report*, 1984
Merino x Deccani	0.74	24.9	-	10.4		Charyulu, 1988
Merino x Deccani	0.61	25.3	-	-		AICRP on sheep, *Annual Report*, 1984
Patanwadi	0.45	29.6	19.1	5.7		Daflapurkar *et al.,* 1979

contd.

Table 10.1. Contd.

Breed	Half yearly wool yield (kg)	Fibre diameter (m)	Medullation percentage	Staple length (cm)	Remarks	References
Patanwadi x Deccani (50%)	0.38	25.3	33.2	6.1		Daflapurkar *et al.,* 1979
Patanwadi x Deccani (50%).	-	35.7	38.1	7.9		Ghanekar, 1983
Patanwadi x Deccani (75%)	-	29.3	27.2	7.2		Ghanekar, 1983
Hamdani	2.00	30.0	9.4	-	Annual clip	Ashmawy and Al-Azawi, 1982 ab
Jaisalmeri	-	36.5	-	-		Chatterjee and Arora, 1974
Karadi	-	48.1	19.4	19.3		Annual clip Ghoneim *et al.,* 1973
Karadi	1.6	28.8	9.6	-	Annual clip	AshmawyandAl-Azawi, 1982ab
Libyan Barbary	2.7	32.5	30.0	13.1		Annual clip Labban, 1973
Magra	-	41.7	-	-		Chatterjee and Arora, 1974
Magra	1.4	-	-	-		Mittal and Pande, 1975
Magra	-	30.8	37.0	-		Sattar *et al.,* 1978
Malpura	-	47.9	-	-		Chatterjee and Arora, 1974
Malpura	0.5	39.0	79.7	6.7		Mahajan *et al.,* 1980 ab
Malpura	0.6	40.6	89.7	5.0		Kishore *et al.,* 1978
Mandya	-	23.0	57.0	4.4		Deshpande and Sakhre, 1987
Mandya x Deccani	-	19.3	40.1	8.3		Deshpande and Sakhre, 1987

contd.

Table 10.1. Contd.

Breed	Half yearly wool yield (kg)	Fibre diameter (m)	Medullation percentage	Staple length (cm)	Remarks	References
Najdi	2.2	66.5	87.8	-	Annual clip	Pritchard *et al.*, 1975
Nali	1.0	-	-	6.9		Ram *et al.*, 1978
Nali	-	30.9	37.8	6.2		Singh *et al.*, 1981a
Nali	-	37.0	80.0	4.5		Pant *et al.*, 1980
Nilgiri	0.8	-	-	-		Bhuvanakumar and Subramanian, 1981
Ossimi	2.1	-	-	11.6	Annual clip	Marai, 1975
Patanwadi	0.45	29.6	19.1	5.7		Daflapurkar *et al.*, 1979

Sulphur content

Barrit and King (1926; 1929) found that the sulphur content of clean dry wool from several breeds varied from 3.0 to 4.1 per cent. Barrit and King (1926; 1931) and Larose and Tweedie (1937) showed that medullated fibres had lower sulphur content than non-medullated fibres, for example lower sulphur content of Deccani wool.

The sulphur content in foreign wools has been reported to be 3.03 per cent by Barrit and King (1929) and 3.6 per cent by Block and 3.21 to 3.31 per cent by Myers (1959). Several authors have reported correlation of sulphur in wool with various features such as length, fineness, age, weathering, feeding, plasticity, etc., Sidsmmonds (1955) found that sulphur content of coarse Merino wool was less than that in the fine Merino wool. It seemed that the sulphur content was a breed characteristics and decreased with the increase in coarseness of the fleece. Apart from nutrition, another factor influencing the sulphur percentage was the amount of medullation in wool.

Albert *et al.,* (1956) observed that the addition of sulfates to sulphur deficient diets increased weight gain in lambs. Indian wool contains 15.5 to 16.5 per cent of the nitrogen, which is almost the same as reported for foreign wools by Bergen (1963).

Reis (1965) reported that the sulphur content of the wool varied from 2.7 to 4.2 per cent. Fine and coarse wools of Merino sheep contained 16.4 ±0.3 per cent of nitrogen (Sidsmmond, 1955) and the wools of Deccani and its crosses 16.47±0.02 per cent nitrogen (Patel, 1967).

Unlike nitrogen, there seemed to be wider variation in sulphur content of wools, from 2.0 to 3.5 per cent. This variation was mainly due to climatic, seasonal and nutritional factors. Nearly 95 per cent of the sulphur was accounted for by cystine.

Marston (1928) reported that the sulphur content of wool was constant at 3.6 per cent. However, Reis (1965) reported that the sulphur content of wool varied from 2.7 to 4.2 per cent. He also reported that under adequate nutritional conditions the sulphur content was between 3.5 and 3.7 per cent.

Mirajkar and Patil (1970) reported wide variation in sulphur content of wools of eleven Indian breeds of sheep to vary wool from 2.0 to 3.5 per cent.

Nandurkar *et al.* (1975) have reported that Autumn clip from Rajasthan, Gujarat, Haryana and adjoining areas from Northether plains were damaged by alkaline suint and this reflected in the lower values of cystine and sulphur content in the wools produced autumn compared to spring clips. They concluded that the higher values of sulphur and

cystine contents of some coarse wools from Deccan plateau may be due to higher degree of Keratinization. The farm wools had higher percentage of sulphur and csystine compared to the wools produced by sheep reared by sheep herdsmen. Thus the scope of improving some of the Indian wools through improved feeding of the sheep is possible. Reis (1965) reported that the sulphur content of wool altered with the changes in nutrient status. Reis and Williams (1965) found that the sulphur content of Merino weathers varied from 3.22 to 3.84 per cent depending upon the type of grazing and productivity of the animals.

Patel (1967) estimated and reported that the percentage of nitrogen was of the same order for the three breeds, namely, Deccani and its crosses with Merino and Rambouillet (mean 16.27± 0.44 per cent). Though there was non significant difference between the sulphur content of the three breeds, the Deccani breed had 3.10 per cent of sulphur, which seemed to be lower than that of Deccani × Merino sheep (3.29 per cent). Chodhury (1983) reported variation in sulphur content from midside sample in Chokla wool as 2.59 to 2.90 per cent in autumn and 2.42 to 2.94 per cent in spring season. Significantly lower level of sulphur in wool was observed from the animals kept on low plane of nutrition.

Choudhury (1985) also reported that sulphur content in this wool of arid zone area sheep breeds, such as Chokla, Magra, Nali, Pugal, Jaisalmeri and Marwari differed from the sulphur content of wool of sheep found in high rainfall areas, such as Malpura and Sonadi. The sulphur content reported by him in respect of Chokla Magra, Nali, Pungal, Jaisalmeri and Malpura and Sonadi sheep was 2.90, 2.81, 2.86, 2.79, 2.83,2.61 and 2.55 per cent, respectively. This may be due to the nutrients in the feed and varying feed intake and climate factors. He had emphasized that his findings were in agreement with the observations made by Lofgreen *et al.* (1953), Hale and Carrigue (1953), Clark and Buhrke (1954), Mathur *et al.* (1970), Reis and Schinekel (1963), Brayand Hemsley (1969), and Barton *et al.* (1971) who claimed that addition of sulphur in diet increased the wool production as well as sulphur content of the wool.

Chowdhary (1983) and Mathur (1984) reported that the distribution of sulphur on the wool fibre and regions of the body accorded with the quality of wool and there appeared a staircase arrangement in productivity with the increase in the total sulphur intake to a definitive intake.

Amino acid contents

Wool fibre grown on the body of the sheep is a scleroprotein

composed of 17 amino acids and proline. It is grouped in the category of keratin. It is well known that wool is composed of a protein required by the sheep for wool production is not very high. The amino acids found in wool are Allanine, Arginine, Aspartic acid, Cistine, Glutamic acid, Glycine, Histidine, Hydroxilin, Leucine, Lysine, Methionine, Tyrosine, Phenylalanine Tryptophan, Threonine, Velinamile nitrogen and Cystine.

Protein content of the diet is greater than 7-8 per cent. The rate of wool growth is independent of protein content and is determined by energy intake. In sheep, protein requirement for maximum wool growth appears to be less than that (10 per cent) required for maximum rate of body weight, but greater than the requirements (6%) for body weight maintain (Nance Reis and Schinekel, 1963).

Mirajkar and Patil (1970) reported that there did not seem to be any difference in the amino acid make up of the Indian wools. Their studies on eleven Indian breeds of sheep revealed that the various amino acids fell within the ranges reported in foreign wools. The only exception to this seemed to be histidine, which was present in traces in Indian wools and higher content of lysine. They also reported wider variation from 1.7 to 61.0 per cent in respect of tyrosine content.

Mineral matter

Copper has vital effect on wool quality. It causes loss of pigment and lack of crimps in wool. Copper deficient wool is weak (steely wool or dystrophic wool). It has abnormal dyeing properties and is difficult to process. Sheep on a copper deficient diet respond rapidly to addition of copper sulfate solution to the skin surface and soon begin to grown normal crimpy wool as reported by Marston (1928). It has been reported by Ryuder and Stephenson (1968) that an excess of molybdenum in pastures can induce copper deficiency in sheep by fixing copper in a form that cannot be utilized. In sheep low copper in diet decreased wool growth but feeding 5 mg of copper per day appeared to increase fibre diameter, tensile strength and crimp ratio.

The deficiency of cobalt has marked effect on sheep as in other ruminants in reducing appetite, thereby indirectly affecting the wool production. Zinc and iron deficiency may cause hair loss in rats, sheep and in goats, but excess of iron may cause degeneration of follicles in sheep, thus affecting wool production.

Mechanical properties of wool

This includes fibre bundle strength, elongation, elasticity, etc. Tensile strength is very high in wool fibre. Its length can increase by 70

per cent when pulled slowly in water. Wool fibres behave differently at high temperature. If a fibre is stretched in boiling water for 30 minutes, it does not return to its original length, when kept in cold water. If it is kept in boiling water for 15 minutes, it decreases in length. Tensile strength depends upon temperature and humidity. It could be 30-40 per cent under arid conditions and 50-70 per cent in humid climate. Felting is observed in wool.

They include fibre bundle strength, tenacity, elongation, elasticity, etc. Chopra (1978) investigated the elastic behaviour of Indian wools at known extensions. The wools were stretched to 2.5, 20.0 and 35.0 per cent of their initial length. He so as to cover the whole stress strain curve, i.e., the Hookean, yield and post-yield regions, chose these extensions. He demonstrated that all the wools under test showed immediate elastic recovery at 2.5 per cent of their extension. Total elastic recovery of the wools ranged from 9.4 to 7.7 per cent at 20.0 and 35.0 per cent of their initial length, respectively. The decrease in the values of elastic recovery for extending 20.0 to 35.0 per cent was 14.00 per cent. The decrease in the values of the work of recovery was 18.0 per cent for similar extension. The immediate elastic recovery in each case was found to be higher than corresponding delayed elastic recovery. The crossbred of Rambouillet × Chokla (75 per cent) behaved almost equivalent to Rambouillet from the point of view of elastic behaviour even at the increase extension. The other cross, namely Rambouillet × Chokla (50 per cent) and Rambouillet × Chokla (62.5 per cent) showed better work recoveries in comparison to Corriedale while the elastics recoveries were almost equal.

Warrier and Iyer Krishna (1979) have reported the bundle tenacity values of wool tops of five fineness grades obtained from the USDA on the stelometer and the instron tensile tester at 3 mm gauge length as detailed in Table 10.2. The data showed that the bundle tenacity values obtained on the stelometer and the instron agreed reasonably well though the former were slightly higher. According to them this difference could be attributed to the fact that in the stelometer the rate of loading remained constant at 1 kg/sec., while in the instron, the

Table 10.2 Bundle tenacity values for wool tops

Fineness grade	Bundle tenacity (g/tex) at 3 mm gauge length	
Stelometer	Instron	Tensile tester
36's	15.14	14.57
46's	13.66	12.88
50's	12.40	11.41
70's	11.50	11.12
80's	11.76	11.13

elongation proceeded at a constant rate. Depending on the stress strain characteristics of the specimen, the rate of loading would vary during the process of extension in the case of instron.

Rao and Chopra (1985) reported the effect of the extent of medulla on stress-strain and torsional properties of single wool fibres. Medulla decreased stress at all the strains. Swelling was less in medullated fibres. Medulla had little effect on torsion at low strains. At high shear strains the medulla collapsed and the fibre failed at low twist. The differences in mechanical properties were explained as due partly to the presence of medulla and partly to the intrinsic changes in the keratin of these fibres.

Dietary factors affecting wool characteristics

There was direct correlation between concentration of plasma free amino acids intake and daily amino acid intake and negative correlation between plasma free amino acid values and wool yield of sheep given the same level of feeding (Efremov *et al.,* 1993). Reis *et al.* (1992) reported that increasing energy supply reduced concentration of urea and essential amino acids in plasma but not that of cysteine or methionine which control wool growth but indicated that there may be a small interaction with energy supply. Methionine is known to stimulate wool growth after trans sulphonation to cysteine, which occurs in the liver; apart from providing cysteine, methionine is reported to specific role in controlling wool growth (Reis, 1982). Protected methionine with doses of 2-6 g daily-improved wool yield by 13-18%. (Potkanski *et al.,* 1985).

Significant increase in fibre diameter and wool volume with methionine supplementation @ 2.5g/d than with 5g/d and in another experiment the fibre diameter and length were significantly better with formaldehyde-protected methionine than with fatty acid protected methionine or control diet without supplementation of methionine (Riley *et al.,* 1991). Significant increase in crimp frequency and other related characters have been observed with cysteine supplementation at feed intake that could produce a useful increase in wool growth; growth was due to increase in length, growth rate of wool rather than fibre diameter (Sherlok *et al.,* 2001). Positive correlation between wool growth and fibre diameter was observed with increase in plane of nutrition and administration of methionine. This result and the nil response at high basal wool growth together with low potential net return on the cost of methionine, suggest the use of methionine could be unprofitable (Stephenson *et al.,* 1991). Motyl *et al.* (1984) and Aitchison *et al.* (1988) observed that growth and wool quality were better with nitrogen supplemented as protein supplements compared to feeding of non-protein supplements. Singh *et al.* (1980) observed no

difference in wool characters in sheep fed diet with or without 1 % formaldehyde treated groundnut cake. The effect of different trace elements on canary coloration of wool has been studied by Ghoshal *et al.(*1979); who reported that mineral deficiency did not appear to cause yellowing of wool.

Factors affecting wool production

Level of wool production and fleece structure may be affected by various climatic factors and seasonal changes which can influence the shedding and regeneration of follicles, fibre diameter and fibre length growth rate (Bhasin and Desai, 1965).

In cold countries sheep is shorn annually. In India it is normally shorn twice a year but in hot states they are shorn thrice a year. Shearing even in warm climate results in change in the microclimate of sheep. Shearing in a warm environment might stimulate wool growth or in cold conditions might bring about a stress response from adrenal cortex. Injections of adrenocorticotrophic hormone (ACTH), cortisone and the application of cortisone ointments depress wool growth.

Humidity and atmospheric temperature: It has been found that humidity differences of 25-30 per cent and temperature differences of up to 30°C had no effect. On the other hand there is a marked correlation between the rate of wool growth and mean atmospheric temperature amongst maiden Corriedale ewes fed a uniform maintenance diet through out the year.

Seasonal rhythm: The seasonal rhythm persists amongst Corriedale ewes fed a ration of constant composition at rates, which maintained the effective body weights of the ewes constant. Marston (1955) found five fold differences in the rate of wool production of fine wool sheep between lush pastures of spring and the poor pasture of winter. The fundamental causes of the seasonal rhythm of wool growth remain obscure.

Photoperiodicity: The ewes produced lesser wool in winter than in summer. Nutrition, pregnancy and lactation can override or magnify the seasonal effect, but it can be isolated and measured, provided these factors, are adequately controlled. The photoperiodicity rhythm may be one factor and it is probable that the seasonal rhythm in temperature may be another.

Hormones : Speculation of the mechanisms involved here is perhaps unwarranted at this stage though the probable connection between hormone output and temperature and photoperiod rhythms may be

mentioned. Atmospheric temperature is known to affect the output of the thyroid. It has been shown that thyroxin administration and deprivation influences wool growth.

The thyroid gland has a permissive effect on wool follicle development and wool growth. Thyroidectomy reduces wool growth to about 40-50% of normal. Administration of thyroxine to normal sheep stimulates wool growth. Dry ewes given a single 60-100 mg implant responded by an increase in wool production by 15%.

Oral administration of L-thyroxine to Suffolk sheep brought about an increase in wool production per unit area of skin due to an increase in fibre length growth rate and also caused an increase in milk secretion during the second to eighth week of lactation in Black Leicester × Scotch Black face ewes.

Cortisol: The main glucocorticoid secreted by the adrenal cortex of the sheep is cortisol and the plasma level of cortisol in the sheep is exceptionally low compared to other species. Administration of cortisol or ACTH to normal sheep suppresses wool growth and complete inhibition can be produced even though the plasma cortisol level remains below that of other species for which the plasma levels are known. Raised levels of plasma cortisol cause "break" and "tenderness" of fleece. Stress conditions such as injury, disease, starvation and extremes of environmental temperature stimulates adrenal cortical secretion and a break in the fleece following such conditions is probably medicated via the adrenal cortex.

Growth hormone: Which has a direct action, does not appear to have a permissive effect on wool growth in that it does not permit growth in hypophysectomized sheep more over it does supplement the response to thyroid hormone in these sheep. Other pituitary hormones such as prolactin, gonadotrophic hormones or oxytocin do not appear to have any significant permissive or regulatory effect on wool.

Physiological status: It has been found to have significant effect on wool growth. In general entire males produce more wool than castrated males, which produce more than females. There is no real evidence, however, to suggest that these differences are determined by anything other than differences in size and nutritional state.

The reproductive cycle in females can reduce wool growth significantly. During late pregnancy, depression of wool growth rate in the range of 20-40 per cent has been found and even in breeds, which exhibit a marked seasonal depression, pregnancy can depress the rate still further. In lactating ewes, wool growth is also reduced by up to 30 percent or more, despite the accepted increase in voluntary intake associated with lactation.

The average reduction in clean fleece weight between handicapped animals (twins and progeny of young ewes) and unhandicapped (singles and the progeny of adults) animals born in the same year was 150 g. The period most sensitive to nutrition deficit is from 30 days before to 35 days after birth (Fraser, 1954).

Age: Rate of wool production in most breeds increases to a maximum between four and five years and then declines, often rapidly.

Nutrition: The most important factor affecting adult wool growth however is the current level of nutrition (Fraser, 1954; Kapoor *et al.*, 1972). Increase in energy intake, except at very low levels of protein content in the diet, can have an immediate effect on wool growth detectable within a few days. It is generally accepted that wool growth rate is dependent on energy rather than protein intake. Wool protein contains a high proportion of the high sulphur amino acid, cystine and it has been shown that variation in the availability of the sulphur amino acids to the follicle can affect both fibre growth rate and fibre composition.

It is not possible to estimate the actual amount of energy, which produces wool. The amount of metabolizable energy which is drawn upon for wool production is likely to exceed materially the combustible energy for wool fibre and of the secretions, which accompany it, which is 3% of the metabolizable energy derived from rations (Marston, 1955). Deficiency of minerals such as calcium and vitamin D are associated with depressed wool growth. These act indirectly possibly by affecting health and appetite.

Carbohydrate supplementation to sheep increases body weight and fleece weight (Fraser, 1954). The addition of carbohydrate to diet converts a negative nitrogen balance into a positive one (Krishnan, 1939). Carbohydrate is necessary for mitosis to take place and there is importance of glycogen in the follicle for wool growth. .

Breeds: In five wool breeds, winter growth rate has been found to be around 85% of that in summer, whereas in British hill breeds the winter rate may be as low as 30% of that in summer. The wool quality of Deccani and their crosses with Dorset and Merinos, Patanwadi and Deccani crosses has been studied by Daflapurkar *et al.* (1979) and Deshpande and Sakhre (1987).The importance of differences between strains and probably breeds of sheep is indicated by recent work with merinos indicating small but significant differences in efficiency of conversion of feed to wool.

The behavioural differences between individual sheep subjected to competition for limited feed, are another source of variation. Feeding

groups of sheep once per week gave higher mean body weights and fleece weights than feeding them equal total amounts on daily basis. Difference of social order within a flock or group of sheep also determines wool production.

Wool shearing

The process of removal of wool from sheep or harvesting of one of the most valuable products of sheep , i.e., wool is known as shearing. A poor job lowers the quality and thus the market value of the wool. To avoid this, the shearing has become a technique rather than a process.

Time of shearing

Wool acts as a protective cover in sheep against heat and cold and it may therefore be shorn at a time when the animal needs it to be done for its comfort. In India, the hot weather begins from March/April and if wool is not shorn then, the animal would not be able to keep its body cool. The sheep are therefore shorn in February/March. Shearing during these months has another advantage that as mating is done after shearing, crutching of ewes and removal of wool around the testicles in rams, i.e., preparation of ewes and rams for breeding is not done as a separate operation.

As the shorter wool dries up quicker than longer wool, shearing is done before the onset of winter, i.e., in September/October. Shearing done in September/October has another advantage, i.e., the wool is not too short when the winter begins and it acts as an insulator as well. Incidentally, wool itself is not a particularly good insulator but air is entangled among the fine wool fibres that most effectively serve the purpose. Therefore, the shearing is generally done twice a year, i.e., in February /March and September/October to provide a protective cover to sheep from heat and cold and also as a cash crop to the shepherd twice a year.

Methods of shearing

Shearing can be done by any of the following methods:

1. Hand shearing
2. Machine shearing
3. Chemical shearing

Hand shearing: Hand shearing is the most common method of shearing under Indian conditions. It is an interesting sight to see an Indian shepherd shearing his sheep. He ensures that the animal is comfortable during shearing as well as clips as close to the skin as possible and

maintains an adequate speed in his operation. An experienced shepherd can shear as many as 40-50 sheep in a day and there are not many cuts on the body of sheep. In advanced countries like Australia, sheep breeder prefers to shear his costly animals by hand shearing to avoid cuts by machine shearing. Shears with sharpened blades are essential to obtain uniform cuts and effect quick shearing. Now shears with a better springing capacity is the handy one available, which saves a good deal of energy and as a result shepherd does not get fatigued and can shear more sheep in a day.

The main disadvantage of hand shearing is that it is time consuming and fleece cannot be cut evenly but it has advantages also. By hand shearing, the fleece can be graded on the basis of individual cuts and can be done at any place.

Machine shearing: Machine shearing in India has been introduced only three decades ago. At present machine shearing is done in the states by respective, Animal Husbandry departments.The shearing, machine is a metal comb over which a cutter is driven. A system of flexible gut, encased and broken by various joints, makes it possible to reach the various parts of the sheep. These machines are either electric or diesel operated.

The main advantage of machine shearing is that it is less time consuming and also works very close to the body and as such economical. But little negligence during shearing can cause cuts or wounds.

Chemical shearing: This technique was developed at USDA Station, U.S.A. by feeding 24 mg/kg body weight of cyclophosphamide, which causes a break in the wool. The wool is removed during a 3 day period starting from 12th day of administration of the drug. But it has been observed that the removal of wool is not uniform. Due to the doubtful effect in the meat causing baldness of the consumer, this method is not used commercially.

Preparation of animals for shearing

The animals must be washed 4 -5 days prior to shearing in clear water to remove the soiled materials. This improves the shearing efficiency, reduces skin cuts and reduces stress on animals. This gives a good market appeal to the wool. The animals should not be either overfed or underfed before shearing. They should be shorn on a clean floor. They should be shorn only two times in a year. The climate should be neither very hot nor very cold at shearing. To prevent canary colouration of wool, they should be shorn in February and July in semi-

arid areas. Wool shorn from abdomen and legs should be kept separately. Sheep should be protected from intense heat after shearing.

Care of sheep after shearing

After shearing sheep may be kept in shade and provided with quality pasture and sufficient drinking water. The feed and water intake increases by 13 to 23% and 11 to 12%, respectively, after shearing. They may be put to routine management practices when they attain about 1" wool on the body surface which is sufficient to protect the animals from solar radiations.

Dipping

Shortly after shearing, an important operation in sheep husbandry is dipping for the control of ectoparasites. The main ectoparasites are tick, body louse and itch mites.

Synthetic insecticides which have greater residual effect on the fleece,

Table 10.3. Medicines used for dipping

Chemicals	Concentration in dipping solution	Remarks
Arsenic sulphate	0.2%	It contains 0.13% soluble arsenic
Nicotin (Tobacco)	0.1%	15 kg tobacco leaves moistened in 500 litres water can be used.
Phenyl	0.76%	It has 0.36% carbolic acid
Lindane	0.031 %	Gamma isomer concentrate solution is used for lambs
	0.05%	This solution is used for adult sheep.

e.g., RH.C. or aldrin are generally used for the destruction of ectoparasites (Table 10.3). Organophosphorus insecticides such as melathion are used due to their high quality insecticidal properties.

Time of dipping

The time when dipping is given to sheep in respect of health of sheep, life cycle of the ectoparasites and the type of insecticide is very important. While shearing some cuts on the body are expected, therefore, dipping should be done 12 to 15 days after shearing so that the wounds or cuts caused during shearing are either healed or scabbed over.

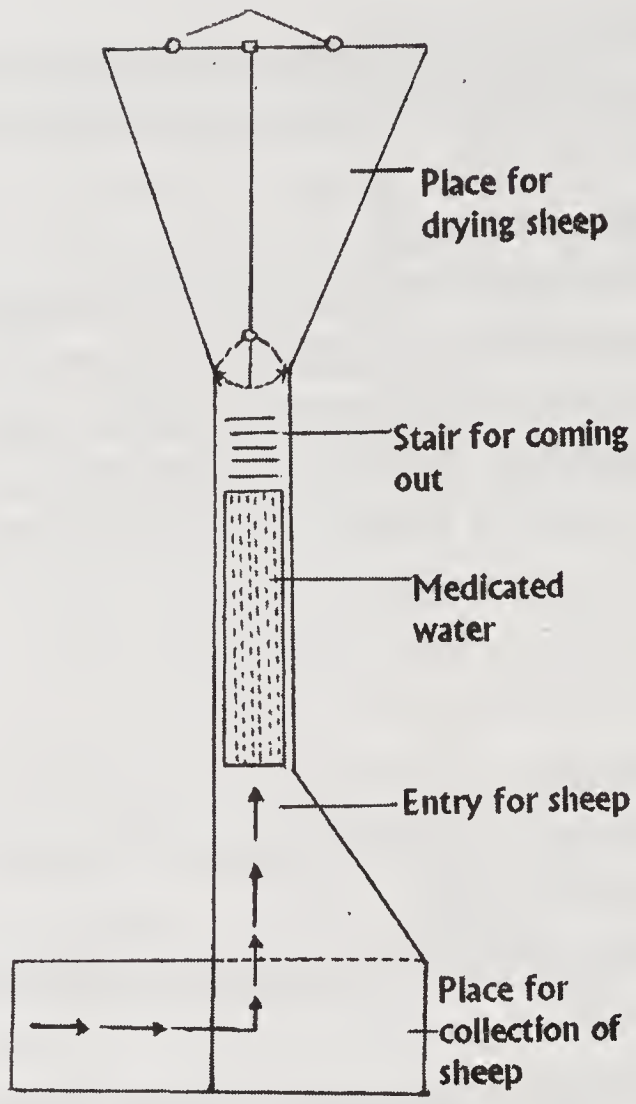

Fig 10.1 Tank for dipping sheep

Sheep dip

Sheep dip (Fig 10.1) is a long, narrow swimming bath, 0.75-1.00 m in width, 1.50 m deep and 0.60-1.00 m long. At the entrance, there is a collection chamber, where, sheep are collected for dipping followed by a forcing pen from where, sheep are driven for dip. At the exit, there is a draining pen. The length of the dip can be increased as checking of sheep in the bath is not good (Fig. 10.1). The floor of the bath, should be made to slope gradually, it should slope backwards. These dips can be made of cement, concrete, or of steel. A fairly big outlet pipe at the bottom is needed to siphon out the liquid and the sediments collected at the bottom. Therefore the dip should be constructed at a higher level. A plug is filled in the pipe. If the outlet is not provided to the dip, then it has to be bucketed out or pumped out to clear it. The dips can be filled either by a pipe from the tap or separate draining pens can be constructed near the dip.

Time in bath

The time, the sheep should remain in the bath, depends on the wool they are carrying, when they are dipped. Half a minute is sufficient for sheep carrying one month's growth of wool. The object is thorough saturation of the fleece to the skin (Table 10.3).

Precautions to be taken dipping are given below

- The dipping bath should be thoroughly, cleaned out some days before the dipping.
- The liquid capacity of the bath should be accurately gauged.
- The directions given for the use of medicines should be strictly followed.
- The bath should be thoroughly stirred from the bottom throughout its length just before the dipping begins; during the dipping and each time new dip and water are added.
- All scum should be skimmed off as it forms.
- Start the dipping early in the morning and continue only so long as to allow all sheep to be dry before evening.
- Sheep should not be thirsty as they are then apt to drink the wash or lick the floor or draining pens. There should be provision of water in the collection chamber.
- Dip the rams first, then the rest of the adult sheep and the Iamb last.
- Dipping should not be carried out in cold or wet weather.
- Care should be taken to see that the sheep are not over crowded in the draining pens. After draining, sheep should be turned out into shed, yards or where there is shelter.
- All the cartoons or packages of dip material should be disposed of before they reach in any body's hands.

Factors affecting quality of wool

Various factors like fineness, length of the fibre, fibre contour, crimp, strength, elasticity felting property, luster, colour, moisture, yield or clean content and medullation either individually or jointly affect the quality of wool, which in turn affects its demand. These factors have been discussed in the ensuing paragraphs.

Fineness: Fineness or the diameter of the fibre is a very important factor affecting the manufacturing quality of wool. Some of the other factors, like length of the fibre, elasticity etc; are interwoven with this quality parameter. The fineness of the wool indicates its elasticity even though it may be of shorter length. The fineness of wool varies from breed to breed and may even vary from lock to lock within the same fleece. The Indian wool fibre exhibits greater variation than the fibres of foreign breeds. There is a positive correlation between the spinning quality of wool and its fineness indicating that finer yarn can be obtained through finer wools.

Length of the fibre: The length of the fibre can usually be measured

expressed in two ways. In the first method, it is expressed as staple length in its time natural form, i.e., with crimp. In the second method, the crimp is removed by stretching and the length is measured, which is known as stretched length. Thus, crimpness is the implicit characteristic showing that shorter wools with more crimpness is preferred to longer wool with less crimp. The ratio between staple length and stretched length varies from 1 and 1.2 to 1.9. The length of the fibre varies not only from breed to breed but also in different parts of the body. Well-bred sheep will produce wool of uniform length than the poorly bred sheep. In the advanced countries, the skirtings are separately collected and through this process even the coarser wool can be separated apart from shorter wools.

Fibre contour: The cross section of wool fibre is mostly elliptical or oval but some times circular. If the contour figure is less than 1.2, it is very good for spinning, whereas, figure of 1.2 to 1.22, it is medium spinning. Another associated quality of wool is the crimpness of the fibre. Crimpness is the waviness of the fibre, which is more pronounced by the number of waves per inch of the fibre length and varies from zero to thirty. Generally, the Indian wool is less crimpy than the wool obtained in temperature climate.

Strength: The strength of the fibre is its breaking strength or tensile strength. The former refers to the force required to effect the rupture of a single fibre or bundle of fibres, whereas, the latter refers to force required to break the per unit area of wool. The coarse wool, is having more strength than the fine wool and the wet wool losses its strength.

Elasticity: It is extension in the length of the fibre without rupture as a result of elongation and partial recovery on subsequent release and regaining of normal position as time passes. It is the percentage of elongation that the fibre undergoes without losing its power to regain its normal length and it can go up to 32 per cent of fine wool. There are two associated properties viz; resilience referring to the property of wool fibre to regain its original position if compressed, which is a desirable quality in the case of carpet wool and rigidity referring to the resistance of wool fibre to a twist which is dependent on the amount of moisture held by it and has a role to play in spinning.

Felting property: It refers to the irreversible entanglement of wool fibres during washing. This is helpful in giving a good finish to woollen fabrics. The fabrics are spun above the required size depending upon the fineness of the fibre and during milling, they shrink to the required size.

Luster: It refers to the light reflecting character of the fibre. Depending on the origin, breed, climate, etc; different classes of wool produce smooth and shining yarn. Glass, Silver and Silk are the different types of nomenclatures used to indicate the degree and type of luster.

Colour: Demand and price are both influenced by the colour of the wool significantly. White wool fetches premium price than the coloured wool. The reason is that the white wool can be dyed to any shade. Generally, most of the North Indian breeds produce white wool of superior variety and South Indian breeds produce coloured wool which is coarse and inferior. The common colours of Indian wool are white, yellow, fawn, grey, brown, rose and black with different shades in between. The colour of wool is mainly influenced by the genetic character and to some extent climatic conditions. Wool produced during rainy season (Shravani Clip) is dirty white and inferior to the wool produced during winter (Chaitri Clip) of the same breed.

Moisture: The moisture absorbing capacity of wool is mainly dependent on the humidity and the temperature. Apart from these, the presence of grease, oils, alkalies, dyes, looseness and compactness also have an influence over it. As the temperature rises, the moisture percentage decreases. At 30% R.H. the moisture content of greasy wool is 6 to 8.5 per cent and at 100 per cent R.H. it is 39.0 to 48.8 per cent. It varies from 11 to 22 per cent at normal temperature of 24°C depending on the humidity.

Yield or clean contents: Wool contains large quantities of impurities, like sand, dirt, dust, vegetable matter such as burrs, seeds, thorns, etc. The sheep gather these impurities as they are reared in sandy or arid areas. Grease and suint (the dried up perspiration) are the other impurities found in the wool of temperate regions. The removal of these impurities is the shrinkage and estimation of correct shrinkage is of great significance and it requires specialized knowledge and judgment.

Hairiness and presence of kemp: Hairiness is not a desirable feature and it is not liked by the textile industry. Some of the undeveloped breeds contain hairs but the improved breeds are generally free from its presence.

Kemp fibres: It is a short, wavy fibre, which is normally shed from follicles. The fibre tapers towards the each end and is dead white or opaque with a large amount of medulla. This exhibits inferior quality characteristic and the fibre is not suitable for textile manufacture as it is coarse and brittle in nature.

Quality of wool obtained from the different parts of the sheep

Well developed breeds and better managed sheep show little variation but undeveloped sheep shows distinct variation in the quality of wool. Generally, the best wool is obtained from the shoulders and sides of the sheep in comparison to the wool obtained from the lower parts of the back, loins and upper part of the legs. The skirtings, which is inferior quality wool, is obtained from the neck to the other portions of the fleece.

Table 10.4 Quality of wool obtained from different part of sheep.

Parts of sheep body		Quality of wool
Top not	:	Very light, short and inferior wool.
Neck wool	:	Very light conditioned and long staple wool also containing coarse matter lumps of inferior wool on the folds
Shoulder wool	:	This is the best wool and generally is used for comparing the wool obtained in other parts of the sheep.
Fleece wool	:	This is wool, which is free from vegetable matter.
Brisket wool	:	Wool from front portions of the belly.
Back wool	:	It is musky wool, which contains sand dust.
Britch wool	:	It is coarser wool compared to the other portions of the fleece.
Arm piece	:	Very short wool surrounded by fribre edges.
Hairy shanks	:	Kemp fibres containing very little wool.
Stained wool	:	This is heavy wool, which is not wash white.
Belly wool	:	It is a good bulky wool, heavy in condition and usually very burry or seed

According to Henry B. Smith, the names of the parts and the different types of wool obtained from them are given in Table 10.4.

Grading and Standardization

Wool even after processing will contain some foreign matter like dirt, dust etc, and sometimes the traders indulge in various malpractices like admixture of wool with other animal fibres mixing of pulled and limed wool clipped wool with clipped wool. To enable the producers to get remunerative prices and help consumers in getting good quality wool, the facilitation service of grading and standardization becomes a necessity. Several wool producing states have set up wool grading and

marketing centres to facilitate the producers in grading their produce. At the central level, the Directorate of Marketing and Inspection has formulated several grade standards for grading wool meant for export.

In the recent years, the quantity of wool graded under Ag-mark is very much limited. The main reason being that now the export takes place in the form of finished products rather than in raw form. This is a healthy sign because it fetches the country more foreign exchange due to increased value added to the raw wool. An important feature of the wools graded under Ag-mark is that wools have a maximum vegetable content of 30 per cent for all wools except for coloured wools, where in the maximum vegetable content permissible is 4 per cent. Export of wool having vegetable contents over these limits is prohibited. It may be mentioned here that the emphasis, which has been solely given the Ag-mark wool, is the yield, without giving any special reference to its quality and staple length.

Grading of wool under agmark

The grading of wool is being done according with the provisions of the Agriculture Produce (Grading and marking) Act. 1937 and Wool Grading Marking Rules made there under. Grading of wool under Ag-mark was started in 1955 in accordance with the Wool Grading and Marking Rules 1953. Grading was done taking into consideration factors like colour, clean content and type of wool. After that the maximum percentages of vegetable matter permissible in lots of different grades of wool have been fixed. At present, grading is being done in accordance with the specifications framed under the wool Grading and marking Rules 1975.

These rules provide nine Schedules for grading different types of wool. Schedule- I prescribe grade designation and special characteristics of Indian clipped and mixed wool. Schedule-III has been framed with a view to allow the grading of Indian tannery wool. Generally, the quality of wool obtained in South India is of inferior quality. In view of this, two sets of specifications have been provided, one for grading of wool other than South Indian tannery and Aden wool with a higher percentage of minimum yield and the other for grading of South Indian tannery and Aden type of wool. Schedule IV contains specifications for grading Indian Hill (Pahari) Wool greasy clipped and pulsed. The grade designation of Indian ginned wool has been given in Schedule V. The Schedule VI contains grade designation of Indian scoured wool and the fineness grades of Indian ginned wool has been given in Schedule, VL A, A specified design of the grade designation mark to be applied on the wool bales has been given in Schedule VII. A specimen of the

Certificate of Ag-mark grading is given in Schedule VIII and specimen of the conditioning Certificate is given in Schedule IX. It can be observed that the different Schedules described above allow for grading of various qualities and types of wool including inferior and mixed wools, which can be graded under Ag-mark. However, it is ensured that the quality indicated by the grade designation mark on the labels affixed to the bales.

Procedure for grading

All parties desirous of packing and grading of wool have to obtain a Certificate of Authorisation for grading from the Agriculture Marketing adviser to the Government of India. The prospective packers have to apply for issue of certificate on the prescribed form through the local authority and the necessary certificates are issued for a specific period after verifying the bonalides of the party concerned. The authorized packers after completing the processing of wool inform the local grading officer before baling and packing the material designed to be graded. The wool is packed and baled under the direct supervision of the Inspecting Officer and labels are issued to the parities concerned to be affixed on each bale. All labels are serially numbered and indicate the grade, colour, yield percentage, count, etc.

Samples are drawn for every lot offered for grading one for determining the yield through core boring machine and the second sample for determining other quality factors such as colour , type ,etc. The samples are sent to one of the Control Laboratories established by the Directorate, which analyses the same and intimates the grade and other results to the grading centres. The grades and other particulars indicated above are stamped on the agmark labels attached to the bales either at the grading centre itself or in case a lot has already been dispatched then at the port of export. A certificate of Grading is issued after marking the results on the Ag-mark labels for each lot. The Certificate of grading has to be shown to the Customs Authorities before exporting the lot to ensure that only properly graded wool is being exported.

It will be observed from the specifications prescribed for grading that samples are to be analysed for a number of factors and require qualified technical staff and special equipment. For the analysis of the samples, Directorate has established two fully equipped laboratories at the major exporting centres of Bombay and Jamnagar. They are working under the control of the Chief Wool Testing Officers and qualified and trained staff means each of these laboratories. The laboratories are equipped with the wool scouring plants, drying chambers and other modern equipment required for the analysis of wool samples.

Skirting and primary classing of wool

Skirting and classing of wool is done on the shearing floor in most of the agriculturally advanced countries. However, there is no such practice in India. As early as 1939-40, the Directorate of Marketing and Inspection suggested simple method of washing the sheep before shearing and skirting coloured and soiled wool from rest of the main fleece. The fleece of the adult sheep and lambs were also suggested to be kept separately, from rest of the main fleece. The fleece of the adult washing and skirting was tried in Jodhpur state on experimental basis and the shepherds obtained 5.7 to 33.2% premium in sale value through these procedures. Though a large number of shepherds were attracted to take advantage of the scheme but due to shortage of supervisory staff and other financial difficulties the scope of the scheme remained limited.

Carpet wool production: About 45 % of total wool produced is from the North Western and Eastern arid region and are available for carpets. Availability of carpet wool is around 22 m kg. The breeding strategy for carpet wool production is through selection within the indigenous carpet wool breeds such as Magra, Chokla, Marwari, Pugal, Patanwadi and by crossbreeding coarse and hairy sheep with exotic or improved

Table 10.5 Greasy fleece yield and quality of promising carpet wool /dual purpose sheep.

Breed	Annual Greasy Fleece Wt. (Kg)	Medullation (%)	Fibre diameter (μ)	Staple length (cm)
Nali	2.08±0.02 (1045)	41.1± 2.9 (49)	29.9±0.94 (49)	6.8±0.34 (51)
Chokla	2.50 ±0.13 (1073)	18.9±2.1 (65)	27.2±0.40 (65)	5.9±2.20 (64)
Avikalin	1.60 ±0.01(1824)	22.1±0.45 (183)	25.2±0.20 (863)	4.2±0.06 (762)
Marwari	1.01	56.1±2.07	38.0±0.99	-
Magra	2.2±0.01 (649)	48.3±0.39 (2968)	32.5±0.35 (2995)	5.8±0.02 (2851)
Patanwadi	1.2±0.03 (139)	34.1±0.85 (277)	27.8±0.25 (277)	5.0±0.76 (293)
Pugal	1.60±0.02 (72)	61.9±0.62 (544)	35.1±1.0 (524)	5.7±0.04 (513)
Mutton synthetic	1.0±0.01 (1298)	39.8 (196)	28.00 (144)	4.4 (127)
Rampur Bushair	1.2±0.06 (47)	23.8±1.30 (185)	34.4±2.7 (185)	7.7±2.05 (185)
Gaddi	0.78 (2650)	25.7±0.32 (2653)	28.5±0.07 (2692)	5.7±0.01 (1245)
Deccani	0.7±0.02 (225)	24.2±1.02 (266)	24.9±1:0.47 (266)	7.0±0.23 (47)
Bellary	1.0 ±0.03	42.41±42 (81)	59.0±1.06 (36)	-

Mean. ± SE figures in parentheses indicate number of observations.

half bred rams. Avikalin is a new carpet wool strain which has been evolved by crossbreeding Malpura and Jaisalmeri with the Rambouillet and by stabilizing the population through interbreeding and selection. Further selection is in progress to balance the medullation percentage and fibre diameter and to improve luster in the wool. Mutton synthetic sheep developed through crossbreeding of Malpura and Sonadi with Dorset and Suffolk also produced carpet wool. The greasy fleece weight and fibre characteristics of different carpet type sheep are presented in Table 10.5.

Development of Grading Systems

To improve upon the traditional wool marketing system and to get higher returns to the sheep breeder and at the same time to prepare the wool clip according to the requirement of wool industry, grading systems were explored and introduced. It was first started under export of raw wool. The grading is based on colour, clean wool yield and type. The general characters described ensure that the consignment is properly cleaned and is free from admixture with other fibres and extraneous

Table 10.6 Wool grading system.

Fineness	Length	Colour	Burr
Superfine A	2" up long	White	L B upto 3%
58^s up	2" down short		
Fine A $54^s/56^s$	2½" up long	Light yellow	M B-3 to 6%
Medium B $46^s/50^s$			
Strong C $40^s/44^s$			
Coarse D 40^s down			

matter.

Under UNDP assisted project, large scale sheep shearing, wool grading and marketing were taken up in the year 1963 in Rajasthan. Wool was purchased by Government, through extension centres and pooled at the wool grading and marketing centres. The wool thus pooled was graded into 90 types as detailed in Table 10.6.

Table 10.7 Wool grading system (I.S.S.2900:1970)

Fineness	Length	Colour	Burr
Below 34.4	A Above 75 mm	White	LB-upto 3%
34.4 37.0	B Below 75 mm	Light yellow	MB-3 to 5%
37.1 to 40	C	Heavy yellow	HB-above 5%
40 and above	D	Other colour	

In addition types of black, greasy, pieces, stainy wool, etc., were, also kept separate. Under the above system wool is graded by trained wool graders under the supervision of bin inspectors and grading officers in the types detailed above. The grading and marketing programme was to be taken up in 8 states and actually it was operated in five states viz.

Table 10.8 Specificaion of wool

Style	Code No.	Description
Good	1	Good colour, yield and sorted. Burr 0-3% good quality and lengths
Good average	2	Yellow wool, nicely sorted, Burr 0.3%, equal in quality and length.
Average Inferior	3	Average yield, nicely sorted, 3-6% Burr. Poor length, burr 6% and more.

Rajasthan, Jammu & Kashmir, Uttar Pradesh, Punjab and Haryana. A nearly similar wool grading system has been evolved at 1.S.1. (1.S.S. 2900: 1970) as given in Table 10.7.

However, no license under IS 2900:1970 now revised to IS 2900:1979, is being operated in the country. The specifications under above grading are given in Table 10.8.

The wools are described as per examples are given below:

- AA - Good colour, 48^{S} quality burr, 0-3% nicely sorted, length above 50 mm.
- B- Yellow wool, 40-48^{S}quality, nicely sorted, burr 3-6%, length above 50 mm.
- CC- Average, 30-40^{S} quality, nicely sorted, burr 3-6%, length above 50 mm.
- DD- Dirty wool, quality below 30^{S}, burr above 6%, length above 50 mm.
- Where A, B, C, and D stands for wool quality, single letter stands for length below 50 mm and double letter denotes length above 50 mm.

Progress of grading

Andhra Pradesh: In Andhra Pradesh, there is no systematic grading of wool. Only while leaning, they sort out wool into 3 grades, based on its size and coarseness. The big sized wool is considered as first grade wool, medium sized as second grade and the coarse ones treated as Third grade wool. The other quality factors that are taken into consideration are colour and texture, which also influence the quality grade of the wool transacted in the State.

Gujarat: In Gujarat a system of grading comprising of 3 grades is followed for internal grading. For this purpose, factors like colour, length of the fibre, burr content, breed, etc., are taken into consideration.

Haryana: Generally, there is no grading and standardization of wool in Haryana, except general observations made towards colour, fineness and cleanliness of raw wool at producers and traders level. The Animal Husbandry Department of the State is doing some sort of cleaning and visual grading. In this process, the factors like fineness colour, staple length, burr contents,etc., are taken into consideration. Two wool grading and marketing centres have been set up at Hisar and Loharu.

It is true that the graded wool fetches good price but the poor producer (shepherd) could not pay much attention towards the quality or the grade. As the marketable surplus is not much and the lot prepared by him is an admixture of various types of wool. it is very difficult to segregate it as per various grades or qualities.

For internal grading, traders and manufacturers generally observe the factors like (i) fineness; (ii) fibre length; (iii) strength of the fibre (iv) elasticity; (v) luster; (vi) colour; (vii) moisture content; and (viii) shrinkage. The importance of factors that will be taken into consideration varies from place to place and as per requirements of the individual buyeRs The classification of wool is mainly on the territorial nomenclatures and colour instead of breeds and types of sheep such as Bikaneri, Beawar, Yaniyambadi, Marwari, Pahadi or White, Yellow, Grey and Black, etc. There is no role of any other agency in promoting grading of wool in the state except the Animal Husbandry Department.

Himachal Pradesh: No grading is done by sheep breeders in Himachal Pradesh. Only Government farms adopt grading and therefore, the quantity of wool graded was much less compared to total production of wool in Himachal Pradesh. The sheep breeders sell their produce as mixed lot except classifying wool on the basis of colour. Cleaning and grading of wool is a must to fetch better price but this will only be possible if some sort of government agency enters the market, educates them and convinces them of the need for undertaking grading and sustaining it for short term as well as long term benefits. In the existing circumstances, it may not be possible for the sheep breeders to grade their produce themselves and offer it for sale, since there is no organised marketing of wool. The reason is that the trading of wool exhibits buyers market rather than sellers market and it may be difficult to predict that the graded wool will fetch higher price. Realising the importance of organised marketing, the Government of Himachal Pradesh has taken necessary steps by forming Himachal Pradesh wool

Procurement and Marketing Federation Limited.

Jammu and Kashmir: Keeping in view the significance of grading, the Wool Board in the State of Jammu and Kashmir has arranged and provided requisite facilities at two of its grading centres located at Naushera and Kartholi. The Board has now envisaged registering wool classers and breeders for the job. They can also conduct the job at different places other than the present centres set up by the Board. Grading of wool, its marketing and proper bailing are very essential for conducting sale of local wool.

Putting own marks of grading by the Board carries out necessary inspections. The grading charges inclusive of all expenses works out to approximately ₹ 2.00 per kg. The Board does the sorting of wool and 1 to 3 per cent losses are observed during the process. Extraneous matters that affect the quality of raw wool are water, sand and dirt. They are usually detected by visual examination only. However, moisture is also measured and controlled by using appropriate mechanical device. Technical know how is already available from grading to combing of wool.

Karnataka: There is no grading and standardization of wool in Karnataka.

Madhya Pradesh: At the field level, there is no grading of wool. Wool grading scheme has not met with the desired success as only coarse type of wool is produced, which is of lowest grade. Moreover, there is no regulated marketing channel at the field level. There are three wool grading and Marketing centres at Shivpuri, Mandsaur and Newari under the Directorate of Animal Husbandry. The wool grading centres in the states are following a system of grading comprising of four grades. Generally, in grading wool factors like count, diameters, staple length and colour are taken into consideration.

Punjab: There is no grading of wool at the producers level. Only black and discolored wool is taken out at the time of making heaps. No grading is done at the time of processing of wool. The cleaning is done by the *Arhatyas* (Traders) and the loss is estimated to be 8-10 per cent in weight due to removal of moisture and foreign matter, dust, etc. There is one wool grading and marketing centre situated at Ludhiana, where wool is graded on scientific lines and after grading, is put to auction. The main aim of the centre is to avoid middlemen and to provide remunerative price to the wool produceRs

Rajasthan: In Rajasthan, a number of grades are followed which are

mainly decided as per local consideration grading of wool, factors such as micron size, length colour, vegetable matter, burr are normally taken into consideration..

Sikkim: There is no system of grading followed in this state. However, some sort of quality parameters are taken into consideration which are as follows:

- I grade-Wool from brisket and belly portion
- II grade-Wool from the neck and back portion
- III grade-Wool from the limbs and other portions of the body.
- IV Mixed grade- Admixture of different grades.

Uttar Pradesh: Grading of raw wool in Uttar Pradesh is done only the Department of Animal Husbandry at their Three grading centres i.e., Mirzapur, Jhansi and Muni. Reti Rishikesh). Among these, Mirzapur centre is the oldest and the other two have started functioning for the last few years only. The quality factors like (a) fibre diameter (b) length of the fibre (c) extraneous matters (d) yield of the wool (e) colour of the wool are taken into consideration by the Department of Animal Husbandry in the grading of wool. Out of a total production of about 17.4 lakh kg (both plain and hill area) only 5 per cent of production is being graded and the rest 95% of the raw wool is being marketed as upgraded.

West Bengal: There is no grading or standardization practiced in the state and therefore no standards are prescribed for grading as only coarse wool is produced.

Appraisal of present grading system

Various research workers have critically evaluated the grading system introduced under UNDP programme. The details of the results on laboratory evaluation indicate that with respect to colour, burr content and length, visual grading is reasonably correct. However, with respect to fibre fineness, there was a very large overlapping and only 34 to 57 per cent of the wool lots could be graded correctly. Visual grading factor, the product of average fibre diameter and medullation percentage, bears a higher correlation with the visual grades than the average fibre diameter alone.

Investigations carried out at Central Sheep and Wool Research Institute, Avikanagar (Rajasthan), also revealed a very serious overlapping of graded wool according to fibre diameter. On the basis of the average fibre diameter, when the different grades were put into quality grades, it was found that there was serious down grading. Some

of the lots that were graded as A or B or C should have actually been graded as 'A'. There were significant differences among visually graded lots in respect of medullation percentage between the wool lots of same grade and also between the different breed wools of the same grade, further reflecting on ineffectiveness of visual grading systems. A very large number of grades, i.e., 90 besides lower lines appear to have added to this confusion.

The Australian wool corporation is now recommending objective clip preparation (OCR) which does not require subjecting the wool to visual classing based on quality, length, soundness, style, etc. It has been seen that within a mob (flock of animals run together and of same age group and sex) there is serious overlapping in the quality of lots assessed subjectively when subjected to laboratory tests and the spinning performance of clip prepared objectively and on traditional systems does not seriously differ. It has been further observed that in Merinos, 2/3rd of the total variation among sheep in the average fibre diameter is accounted for by the variation between fibres within a staple.

Wool Packaging

Wool is packed mostly in gunny bags. Some times, it is also packed in bales in few states. For export purposes however, it is mostly baled. The size of gunny bags or boras varies from state to state and in most of the states long gunny bags made of three or four gunny bags are used. Their capacity varies from 100 to 160 kg. The gunny bags give packing material because it is economical. The cost of packing also varies from state to state. The overall packing losses are estimated to be 1 to 2 per cent judging by the experience of most of the states.

In Andhra Pradesh old jute bags serve as packing material. The size of packing is ranging between 150 and 180 kg. The cost of packing works out from ₹ 8-10. There is a loss of about 1 per cent in the packing of wool.

In Gujarat, jute bags of size of 1.0 × 2.5m with capacity of 100 kg are used for packing of wool. The cost per unit (jute bags) is ₹ 25. The quantity lost in packing was 0.5 kg per bag with a value of approximately ₹ 12. The overall percentage of loss in package was reported to be 0.5 percent. Old gunny bags are also used in packing of wool, as it is economical compared to all other materials. The gunny bags in fact serve as packing material at all stages of handling. The size of containers usually demanded by foreigners is with a minimum of 110 kg. The foreign wool traders are using the polypropylene bags for packing.

Generally for packing of wool at all levels, second hand jute bags are used in Haryana. A small quantity of raw wool (20-25 kg) is packed in jute bags as such. While large quantity of wool in packed in long bags.

It contains 100 to 120 kg of wool or sometimes even more depending upon the quantity of wool. Wool is pressed in bags by applying foot pressure. Generally this process is carried out manually.

Second hand jute bags are easily available in local markets. It is coasting about ₹ 4 to 5 per piece. For indigenous use, jute bags are suitable and economical. It is easily available locally at a cheaper rate in comparison to other packing materials and it can be used for the same purpose for a number of time.

The wool grading and marketing centres of Animal Husbandry Department of Haryana at Hisar and Loharu using second hand polythene bags coasting ₹ 40-45 per bag, packing 90-100 kg of wool by hand pressing machine.

In Himachal Pradesh, jute bags are used as packing material. The size of the jute bag is small and can pack about 20-25kg of wool. The cost of packaging per bag is estimated to be ₹ 10. The packing losses are not significant.

In Jammu and Kashmir, the packing of wool is in bails. The size of packing is 1.0 × 0.5m and 0.5 × 1.0m. The cost of packing of the former works out to ₹ 4.50 per bale and ₹ 18 per bale for the latter. There is no report of packing loss.

In Madhya Pradesh, mostly jute bags are used as packing material. Sometimes, imported second hand HDPE woven bags are used, some of which have the capacity to pack 25 to 50 kg of wool, whereas, other variety can be used for packing 90 to 100 kg. The cost of packing is ₹ 2-3. in case of former and ₹ 15 in the case of latter. The quantity lost in packing is reported to be negligible.

In Punjab, jute bags are used as packing material for packing wool. The size of packing is 10 to 40 kg. The cost of packing works out to ₹ 10-40 per bag. The packing loss is reported to be negligible.

In Rajasthan, wool is packed in jute bags of 0.75 × 2.0m costing ₹ 20 to 30 per bag which can be used three to four times. The expenditure on account of iron clips is around ₹ 13.50. It may be pointed out that one such jute bag is normally made of 4 gunny bags, containing 100 to 150 kg of raw wool. The packing losses are 1-2 kg and in terms of value, it is ₹ 30-45. The packing losses work out to approximately 2 per cent of the total produce. Apart from jute bags hessian cloth is used for pressed bales, which are to be sent outside the state for export. It contains 145-150 kg of raw wool. This is the most suitable type of packing wool, which facilitate handling.

Raw wool is normally packed in long gunny bags made of jute fibre containing up to l00 kg. In Uttar Pradesh, the State Animal Husbandry

Department packs upto 60 to 80 kg. The cost of gunny bag is ₹ 20 to 25. The quantity of wool lost in packing is reported to be negligible.

In West Bengal, jute bags and cloth serve as packing material. The capacity of jute bags is 2 to 5 kg for door to door collection. The packing cost works out to ₹ 1-2 for old gunny bags. The packing loss is estimated to be 1-2 per cent. The capacity of bales is usually 50-100 kg and the cost of baling is ₹ 10-20.

Storage

Storage increases time utility of any agricultural or allied produce. Wool is stored mostly in gunny bags. The producers and middlemen generally store wool for a period of one or two months in their own houses. Other agencies stored wool for a longer period of 8 to 9 months, at times upto one year. The relevant position in various states is explained in the ensuing paragraphs. The storage loss is estimated to be about 2 per cent in most of the states during normal times and goes up to 5 per cent during rainy season.

In Andhra Pradesh the storage of wool largely depends on the crop season. The producers as well as traders store wool in private godowns only.

The storage facility created for wool in Gujarat is mainly by the state government. Normally, the wool is stored in bags. The storage capacity created is to the tune of 7,000 quintals. There is cent per cent utilization of the storage capacity thus created. The storage loss is around 2 per cent. The loss occurs mainly due to moisture. Generally wool is stored during the months of August to November. There is no cost involved in storage since the Government owns the storage space. Only establishment maintenance costs are incurred.

In Haryana, the producers store their wool approximately 50 to 100 kg at their own kacha house in gunny bags for a period of 1-2 months till it is finally sold locally or in the wool, market. Generally, there is no significant loss during storage and also there is no storage cost involved at producers' level. However, during rainy season losses do occur due to humidity and a pest called 'sundi'.

The middlemen collect 20 to 25 kg of raw wool from producers and keep it at their own houses in long gunny bags. They store upto 10 quintals for a period of 1 to 2 months. There is no storage charges or losses involved except in rainy season when losses may occur up to 5 per cent due to the wool pest mentioned earlier.

Wholesaler or commission agents also store the wool in their own or rented godowns, which are pucca or bricked, for a period of 2-6 months, when it is necessary to store the wool. Normally, they keep the raw wool in long gunny bags of 100 to 120 kg or more. Storage charges

are ₹ 5 to 10 per month/bag. Storage losses are reported to be 2 to 4 per cent due to moisture loss in dry weather and up to 5 per cent during rainy season due to a pest called "Sundi".

The Animal Husbandry Department of the state stores the purchased wool for a period of 2-6 months before it is auctioned. They have their own cemented godowns to store the loose or baled wool. After cleaning and grading, the wool is stored in pressed bales of 90-100 kg. Generally there is no storage loss except moisture loss. There are no godown charges, as the department owns the same.

In Himachal Pradesh, the storage capacity is entirely in the private sector and exact figures under various counts are not available. Storage of wool is mainly in bags.

In Jammu and Kashmir, the state government creates the entire storage capacity. The storage is mostly in loose form. The storage capacity created is of the order of 5,500 quintals. There is 100 per cent utilization of the storage capacity created. The Storage period ranges from 6 months to one year. The average cost of storage is estimated to be ₹ 43-63 per quintal.

In Madhya Pradesh, private parties, Cooperative Societies, State Government and Khadi Institutions, have created the storage capacity. In the private sector, the wool is stored both in loose form and in bags. The capacity of storage in this sector is 100 quintals of which 50 per cent is utilized. The storage losses are reported to be negligible. The raw wool is stored for a period of 2-3 months. In the storage of the Cooperative Sector, the wool is stored in bales and bags. The capacity of storage space in this sector is also around 100 quintals only. Almost 70 per cent of the capacity is utilised. The period of storage ranges from 3 to 4 months. The storage capacity created by the State Government is of course quite large to the tune of 7,000 quintals, of which only 10 per cent was being utilized during the period of survey. There is no report of storage loss. The period of storage ranges from I to 2 years

The Khadi institutions have also created a storage capacity of 2000 quintals. There is a capacity utilization of 75 per cent. In this case also, there is no report of storage loss. The normal storage period is usually of 3 to 4 months.

In Punjab, entire storage capacity is in the private sector. The raw wool is stored in jute bags. The capacity of the storage space is 3000 quintals.

In Rajasthan, the storage capacity has been created mostly in the private sector. The godowns created for storage are pucca. The capacities of the godowns are 15 to 50 quintals. The capacity utilization ranges from 75 to 95 per cent. The storage losses are reported to be negligible.

There are moisture, dust and discoloration. Hence, there is need for proper storage to avoid losses. The period of storage in godowns ranges from 10 to 30 days.

In Uttar Pradesh, the producers store their wool up to a maximum of 50 kg at their *'kucha'* house for a period of 1 to 2 months till it is collected by the local traders Gunny bags serve as packing material. Generally, there is no loss during storage and no storage cost is involved a this level. During rainy season, loss occurs clue to humidity and the pest called "Sundi".

The middlemen or local wool traders collect raw wool approximately 20-25 kg from the doorsteps of each producer and keep the total quantity thus collected at their own house in long gunny bags. They store, upto 5-10 quintals for a period of 1-2 months till it is marketed. Normally, no storage cost or loss is involved at this level but during rainy season, due to humidity, losses occur up to 5-10 per cent caused by the wool pest caned "Sundi". Wool being hygroscopic in nature absorbs moisture and creates atmosphere conducive for the growth of the wool pest.

The storage facilities provided by the Animal Husbandry Department were having a total capacity of 1,500 quintals. The godowns are owned by the Department and hence: there is no storage cost involved. Usually, there is 100 per cent utilization with a reported loss of about 2 per cent. The wool is stored mainly in gunny bags and some time in bales. There are about 16 major KVIC aided institutions in Uttar Pradesh. These institutions have 20 big size pucca godowns with a capacity of 1000-1500 bags of 50 kg each and 20 small pucca godowns with a capacity of 50 bags each. All the godowns are owned by the KVIC.

After analyzing the position prevailing in various states, the following measures are suggested to avoid/reduce the loss of wool during storage:

(i) Storage should be avoided during rainy season;
(ii) Wool should not be stored for more than 6 months to avoid qualitative and quantitative losses;
(iii) Wool should be stored in pucca godowns;
(iv) Wool should not be kept in loose or in open places; and
(v) Bales or bags should be kept on wooden platform in the godown.

Damages during storage

Damage to wool can occur due to microbiological attack by insects, exposure to moisture, etc., By contamination with micro-organisms, wool is prone to deterioration of multiplying rapidly under favorable conditions like temperature and humidity, which would cause the wool

fibres to be stained with mildew or to lose strength. It has been reported that disintegration of wool fibres can take place by action of enzymes, which affect the scales of the fibre. If wool bales come in contact with water, fungus develops.

It has been reported that the presence of alkaline content in various soaps, wool grease and majority of conditioning fluids may increase mildew development caused by fungi. In hygroscopic soaps, moth growth can occur over a wide range of humidity. Besides, this, it can occur over a wide range of pH since both acid and alkali conditions favour the same. The greenish yellow stains commonly found on wool are due to the action of the soaps. Mineral oils have a protective effect. Lower fatty acids retard moth growth, whereas, more complex fatty acids favor growth.

If wool is stored in a warm place, in a moist alkaline condition without any air circulation, bacteria start to grow and produce enzymes, which can rapidly attack the fibre. Some research workers have found that wool which have neither been injured mechanically nor modified chemically, is, the wool becomes susceptible to enzymes. When the wool scales are damaged by mechanical means, the wool becomes susceptible to enzymes. Even though, the very small portion of the wool is digested, the fibres are considerably weakened and their structure partly destroyed. Due to bacterial action, large amount of heat is generated and temperatures as high as 60°C have been measured inside bacterially attacked bales.

Wool like fur and feathers is vulnerable to attack by moth larvae in certain conditions, which are favorable for the growth of moths. It has been estimated that the progeny from a single female moth might, under favorable conditions for reproduction, eat about 42 kg of wool in a year. In wool industry, even in more advanced countries no control on the considerable damage caused in the warehouses has been practicable. An ideal moth proofing agent is that which provides permanent protection to the wool fibres from the moth attack. The moth proofing of wool and other animal fibres is effectively achieved by the impregnation of the fibres with chemicals that make unusable as food by moth larvae. The widely used insecticides, however, have proved very effective against moth. Concentration of 0.1 to 0.15% is effective on wool and has been used in the mills and in dry cleaning in spray form.

The new insecticide "Dieldrin" has shown itself to be an effective moth proofing agent. As little quantity as one part in one thousand by weight of the wool, has proved a sufficient protection. The mothproofing agent should not be toxic to human being. For this reason, arsenic derivatives are not used.

Apart from the consideration of the ideal conditions for storing wool, the matter of specifying some quick test for assessing chemical damage due to bacterial or moth attack is also essential to serve as quality control during wool storage.

Transportation

Transportation plays a vital role in the marketing network of agricultural and allied products and wool is no exception. Unlike most of the agricultural or allied products, the rearing of sheep is of migratory nature and shearing of wool takes place mostly in inaccessible areas. Hence, all modes of transport like head loads, mules, bullock carts, hand carts, camel carts and sometimes the sheep it self is used. Wherever *pucca* and *kacha* roads are available, motor driven vehicles are used. In the desert areas, camel cart continue to be used for transporting wool. For carrying wool to the markets in high altitudes, yaks are used. In some of the hilly tracts, males are the only mode of transporting wool. In the plains, bullock carts, handcarts, bicycles, etc., are used for transporting wool from the producing areas to the assembling centre. From the assembling areas to the terminal and wholesale markets, wool, is transported by tempos, matadors, buses and sometimes by trucks. Generally, the truck is used for long distance transportation within the state. Occasionally, it is transported by rail also. As far as the inter state movement of wool is concerned, it is transported mostly by road through trucks and a lesser quantity by rail. Even though, the cost involved in road, transport is more as compared to rail freight it is preferred because the wool can be taken directly from the godown of the seller to that of the purchaser. Morever, the road transport ensures safety to the produce, saves time in transit and relieves unnecessary botheration of transhipment.

In Andhra Pradesh, tempos/matadors are used for transporting wool to shorter distances to bring the same to the nearest assembling point. Smaller quantities are also carried as head load or by bicycles. For up-country markets, the export takes place by using rail/road transport.

In Gujarat, trucks are used for transporting wool to the distant places, which are located more than 100 km away. However, tempos are used for transporting wool to shorter distance. Transportation by rail is also used to a certain extent although popular mode of transport continues to be road only.

Transport situation in Haryana is quite satisfactory and wool is transported mainly by-rail and road. Most of the villages of the state are connected by pucca road to the main towns. Road transport is costly in comparison to rail transport, however the road transport is quick and goods can move from door to door.

As per the trade information, road and that transport more than 55 percent of wool too mainly by trucks and matador. Matadors or tempos mainly transport wool from far off villages. Wool from other states is brought by road or rail, the ratio being 60 per cent by trucks and remaining 40 per cent by rail.

Generally losses during transportation of wool are very negligible except when the gunny bags are mechanically damaged or torn and the wool comes out from packing. To minimize this, bags should be sound and properly stitched. In Himachal Pradesh, there is no market for wool and the information on this aspect is therefore not readily available. However, it was revealed during the survey that the sheep breeders carry their produce on pack animals. The same is purchased by wholesalers who in turn transport it by matador, tempo or truck to distant markets/ centres depending upon the distance and quantity to be transported.

In Jammu and Kashmir 6 per cent of the wool is transported by pack animals involving a distance of upto 10 km, 74 per cent by trucks for a distance less than 200 km and 14 per cent by matador if the distance is less than 100 km. The average rate per kg/km. works out to ₹ 1 in the case of pack animal, 0.65 paise by matador and 0.15 paise in the case of trucks. The transpiration losses are negligible. The Wool Board, which is the only procurement agency in the state, has set up 2 grading centres, one at Kartholi and another at Nawshera. Transportation from producer's and to the collection centre is effected by the producers themselves on their ponies or on the back of the sheep. Inter state movement of wool is done mostly by trucks.

In Karnataka, there is no regulated or unregulated markets for wool and therefore, no systematic information is available on the subject. However, the state is having adequate and satisfactory network of roads, which meet the transportation needs of the wool sector also. Trucks, matadors, tempos, etc., are used depending upon the size of the consignment as well as the distance to be transported.

In Madhya Pradesh, there are no primary, secondary or consuming markets for wool. Hence, specific information could not be collected in detail. However, it was gathered that weavers affect transportation of wool from villages by cycle, bus or trucks. Arrivals from outside the state come mainly by trucks.

In Punjab, the shepherds mostly bring the wool from their villages to Abohar or Fazilka by the state transport and private buses. The producers to the regulated markets of Abohar and Fazilka bring some quantity of about 10 to 12 per cent by rail. The approximate transportation cost as reported by the producers comes to ₹ 6-8 for 40

kg of wool. Inter state movement is effected by rain or road with the trucks getting preference over other modes of transport.

In Rajasthan, trucks, matador, tempo, rail, bus and camel cart are used for transporting the wool of which the trucks share is around 60 percent involving a distance of 200 to 400 km, Matador and tempos are used for distances between 150 and 200 km and their share is 14 per cent. Another 14 per cent is transported by bus for distances above 50 km. Camel carts are also used for distances within 50 km and their share in the total transportation of wool is around 10 per cent. The remaining 2 per cent of wool is transported by rail for distances above 400 km.

As far as the inter-state movement is concerned, imports are mainly from Gujarat and 10 per cent of it comes by rail at the cost of approximately 20 paise per kg and the rest by trucks at the cost of about 40 paise per kg. Exports are mostly to Uttar Pradesh and to a lesser extent to Haryana, Punjab and Delhi, which is usually effected by trucks at the transportation cost of about 40 paise per kg.

In Sikkim, there is no market for wool and therefore, specific information on this aspect is not available. However, it is understood that depending upon the quantity, the wool is carried by pack animal or through ponies, tempo and matador.

In Uttar Pradesh, generally wool producers are not bringing directly their produce to the market. The itinerant merchants themselves go to the producer's doorsteps and buy small quantities approximately 15-20 kg and bring it to their own house by cycle. Generally, after collecting adequate quantity of wool i.e. approximately 200-300 Kg, these traders bring it to the nearest wool markets by truck at the rate of 0.25 paise/ kg/ km. Sometimes, they also bring raw wool in gunny bags to the market on camels at the rate of ₹ 20/50 kg/10 km

It is reported that approximately, 80 per cent of the wool is transported by trucks and the remaining 20 per cent by camels. As regards inter-state movement of wool, it is revealed that 65 per cent of raw wool produced in plain areas of Uttar Pradesh is exported/transported to Haryana and Punjab especially to Panipat wool market by rail and the remaining 35 per cent by trucks. About 55 per cent of total raw wool is being imported from Rajasthan. Out of this, 75% is transported by rail. Almost 60 per cent of the black wool transported from south India is by trucks and the remaining 40 per cent by rail. Woollen yarn from Haryana and Punjab is being imported solely by truck.

Since the wool is produced in the villages that are isolated and there is also no primary, secondary or consuming market in the state especially

for wool, the same is collected by the agents of the wholesale traders, who carry it to the wholesaler's godowns by cycles or bus depending upon the distances involved in such transportation. The wholesalers send the wool thus collected to the producing areas of woollen in Uttar Pradesh or other States by rail/road.

Preparation of Clip for Sale

Sheep with its multifacet utility producing meat, wool, skins and manure, plays an important role in the national economy. This is especially important in arid and semi arid regions with marginal and sub marginal land unfit for agricultural production even using modem sophisticated methodology for water and soil utilization. The arid areas in India cover more than 3.2 lakh square kilometers Sheep is the most important livestock for using the sparse vegetation available in arid and semiarid regions of the country.

India has about 50.8 million sheep producing nearly 49 million kilograms of wool. Out of this production, about 15 per cent is of finer quality and could be suitably used in combing process and rest of the wool is either of carpet quality or suitable for woollen manufacture only.

The state of Rajasthan occupies a unique position in respect of wool production in the country. It has sheep population of 14.58 million according to the livestock census of 2003 and the estimated wool production is about 17.8 million kg. This quantity represents about 41 per cent of the total wool produced in the country. Because of non organised channels in which to orderly market their products; the state is not receiving fully economic advantage, it would derive if established markets were set-up.

To effectively prepare the Indian wool clip for market, which could meet the requirements of trade and at the same time to ensure fair price to the sheep breeders, large scale sheep shearing, wool grading and marketing programme was started in the year 1964-65 in Rajasthan, Punjab, Haryana, Uttar Pradesh, Jammu and Kashmir, Gujarat, Madhya Pradesh and Maharashtra.

The UNDP programme was started in Rajasthan in 1964 and one Project Manager along with a team of 4 Australian experts remained in the state for a period of 5 yeaRs Later, this team extended its operations in other states mentioned above in a phased programme. Prior to the introduction of wool grading programme under UNDP, wool was classed and graded under Ag-mark scheme sponsored by the Directorate of Marketing and Inspection, Ministry of Food and Agriculture, Govt.

of India and it was regulated under the Agriculture Produce (Grading and Marketing Act 1937). The actual wool grading and marketing Rules 1961 were confirmed and it stipulated the grading of wool on the following lines. This grading was taken up predominantly for export of wool from India to the continent and the USSR

Different Types of Live and Dead Wools

Sheared or clipped wool: The clipped or sheared wool can be obtained from the adult sheep or lamb. The wool obtained from adult sheep is called live wool or virgin wool and hoggets wool is obtained from lambs. The wool obtained from, lamb is of finer quality. The hoggets wool has more vitality and elasticity. It is superior wool with better weaving qualities. The fleece is less dense.

Pulled and tannery wool: This is the *desi* wool obtained from the skin of slaughtered animal by different methods. Pulled wool is the wool removed from the pelts of slaughtered animals irrespective of the process adopted.

Pulled wool: The fleshy side of the woolly skin treated with lime, salt or sodium sulphite. After some time, the wool is pulled as the roots get weakened. The wool obtained by this process is costly as well as inferior to fleece wool and locks spinning properties. As compared to the fleece wool, it is harsh brittle and less elastic.

Tannery wool: The skin of dead animals after cleaning of flesh portions are painted with slaked lime and completely soaked in lime bath. This is washed after some time and wool is, obtained by scraping with iron scraping knives. As compared with the pulled wool this is not a costly process. The pulled wool or tannery wool constitutes on a small portion of the total wool production and is not having much commercial importance.

Other designations which are incorporated under Ag-mark scheme included Indian-Mixed wool, clipped graded, clipped carded, clipped pulled, hill wool clipped, and Indian ginned wool.

An important feature of the wools graded under Ag-mark is that these wools have a maximum vegetable content of 30 per cent for all wools except for coloured wool, where in the maximum vegetable content permissible is 4 per cent. Export of wool having vegetable contents over these limits, is prohibited.

It may be mentioned here that the emphasis, which has been solely given to agmark wools, is the yield, without giving any special reference to its quality and staple length.

The wool produced in the state of Rajasthan ranges qualitatively from medium to coarse types. The fleeces obtained from sheep, though vary greatly in length and fibre fineness, are most suited for carpet manufacturing. About 15 per cent of the total production of the state may be used for the manufacture of apparels and blending this type of wool with imported wool may produce also better type of fabrics.

There is a vast scope for the development of wool industries in small scale as well as large/medium scale sectors, but the entrepreneurs may face difficulties in regard to supply of standardized wool, which may only be overcome through effective preparation of wool clip for market to enable the manufacturers to get required type of wool and at the same time the producer getting fair prices for the produce.

There are eight breeds of sheep in Rajasthan-namely, Chokla, Magra, Marwari, Jaisalmeri, Pugal, Malpura, Nali and Sonadi. Some of the Marwari and Magra sheep are shorn thrice a year; otherwise, all the sheep are shorn twice a year. The sheep, which are shorn twice a year normally, give long staple wool to the extent of 70 per cent and the remaining 30 per cent may be classified as short staple wool, pieces, black, stains and dogs, etc.

Under the existing conditions, the wool is sold to the merchants in a mixed form and no grading is done at the shearing point. The shepherd is more or less under the financial control of the local merchants because he depends upon them for his very existence. The shepherds are usually poor and illiterate, knowing little of the outside world and because of no organised market, sell their produce, they had to look to the local merchants to take over their commodities.

In the stores of the wool merchants in market, they employ the labourers for simply separating the white wool from yellow and for removing whatever black wool they see. Heavy burr is also removed from the wool by clipping with scissors The wool is then pressed and is sold to the local manufacturers

The authorities have no control over the markets whereby the shepherds, could offer his produce through organised channels and get better price for their wool. The unfortunate shepherd has to take whatever the village merchant offers to him. One can easily imagine that price at which it is first bought from the breeder is well within the profit range for the merchant. Under this order, the nation is not receiving full economic returns from its wool industry as profit is going in the hands of a few.

In Rajasthan wool has been included as agriculture produce and regulated under the Krishi Upaj Mandi commodities, but it has not been operative in big market like Bikaner so far. Under the large scale sheep shearing, wool grading and marketing project taken up by Rajasthan and

eight other states, the wool is purchased by the department of Sheep and Wool through its extension centres. To some extent, the sheep are shorn by an organised method of mobile machine shearing units of the department.

This wool is then packed in big jute bags and dispatched to wool Grading Centres, where the trained wool graders in standard wool types grade it. These standards are based on the Australian system, which conform to world wool requirements. When the grading of wool is completed, it is pressed up in standard wool bales keeping each quality separate. It is then catalogued in order of merit showing the number of bales, the qualities, length of staple, the colour and burr contents of the wool in each lot.

The separated show bales, which are representative bales of the entire lot, are shown on a show floor in order in which it is printed in the catalogue so as to make convenient and easy for the buyers to inspect and value each lot independently. After the inspection of the wool is completed, the wool is offered in separate lots by public auction and sold to the highest bidder.

It is very essential that grading programme, which was taken up over the last decade, is properly streamlined and grading is done looking to the demand of the manufacturers If sufficient attention is not paid to keep the various wool grades uniform, the buyers hesitate to pay correct price for it.

Under the large scale sheep shearing, wool grading and marketing programme started in many states of India, wool are graded mainly in 5 basic qualities,.i.e., superfine, fine, medium, strong and coarse. They are further classed according to length, colour and vegetable contents. Greasy wools are graded separately and lower line (wools of belly, legs, stained wool) are kept separately and graded in various types. Thus, in all, about 90 types are made out of Indian wools.

Wool lines in vogue at present are as under:

Washed wools

	Super fine AALB	Fine BBLB	Medium CCLB
AASLB	Super fine AAMB	Fine BBMB	Medium CCMB
AASMB	Super fine AARB	Fine BBMB	Medium CCRB
	Strong DDLB	Coarse	
	Strong DDMB		
	Strong DDHB		

Colour

White, light yellow and heavy yellow burr contents.

LB 0 to 3 per cent
MB 3 to 6 per cent
HB over 6 per cent

Colour (BRANDS)

Black
Pcs.,
Stns.,
Cotts.

Greasy wools

AAGSY fine and medium
BBGSY Strong and coarse
Burr contents
LB
MB
HB

All the above types are also made in short lines and indicated by one alphabet,. i.e.,

As- Superior fine short
A Fine short
B Medium short
C Strong short
D Coarse short.

Purchasing and selling of wool is essentially based on its yield contents. It means that if 100 kg of wool is purchased and when scoured it would give clean wool content, which may range according to the type of wool scoured. During washing, the impurities like grease, dust, sand/ suint, etc., are washed away and clean wool remains. Normally under our conditions, the sheep are washed 2-3 days before shearing. This wool is called washed wool. The other category of wool is from those sheep, which are not washed. This wool is termed as greasy or unwashed wool. In the washed wools, normally we get a yield of 70-80 per cent and this is also influenced by length, quality, colour, amount of grease, vegetable matter, dust or sand, density and to some extent the type of tip.

Finer the wool, the lesser the yield and coarser the wool, higher the yield. Our wools are heterogeneous in nature, i.e., a fleece of wool obtained from sheep has 3 to 4 qualities in it and therefore, the yield assessment has to be based primarily on the main quality of wool found in that particular fleece. Other factors which influence the yield of wool are suint, vegetable matter and dust which is directly related to the type of washing practiced and the presence of inferior grades of wool in a particular quality of wool. All these types will be packed in *boras* (bigger

gunny bags), and dispatched to the Wool Marketing unit of the federation where, required grading will be done and wool dispatched off.

Utilization of Wool

There is a wide variation in the quality of wool produced by sheep reared in different agro-climatic conditions of the country. The quality of wool varies from 40's to 60's spinning quality in the wools grown in the Himalayan and dry Northern regions, while the wools produced by the sheep of the Southern regions are coarse and coloured. Annually, about 9 to 10 million kg is exported as carpet wool earning valuable foreign exchange, while the country imports finer types of wools to the extent of ₹ 120 million. Due to restrictions on import, larger quantities of indigenous wools are being utilised in the various sectors of the textile industry. The estimated utilizations being 7 million kg in the organised mill sector, 7 million kg in the blanket manufacturing industries. Considerable difficulties are, however, experienced in the utilization of the wools for the manufacture of quality products.

In order to make larger quantities of better quality wools available for the indigenous industries and for export, a wool-grading programme is being undertaken in Rajasthan and other wool producing states. Under this programme, the wools are graded on the basis of quality, the quality being assessed by subjective methods such as colour, etc. The ultimate utility of these grades for the manufacture of various end products is not yet known. The sheep improvement programmes undertaken in the country envisage crossbreeding of local coarse wooled sheep with exotic fine wool type to produce fine type of wools. The manufacturing trials on these wools will elucidate the correct utilisation of wools already produced and the new type of cross bred wools and also the extent to which blending of different types is desirable to ensure the required properties in various end products. This would result in less dependence on finer type now being imported, in increased exports simultaneously bringing more financial returns to the products of quality wools.

Role of quality in affecting demand

Classification of wool on the basis of qualities factor elaborated in the proceeding paragraphs, a must to obtain full value for the produce. Quality is a major factor, which affects demand both internally and internationally. In the advanced countries marketing of wool is organised and the fleeces are classed at the shearing centres and wool of different qualities are separately pooled. It may be mentioned that there is no systematic classification of different type of wool based on the quality factors such as fineness, fibre length, etc. It is commercially graded on

the basis of territorial nomenclature and colour. The indiscriminate mixing of fleecing which yields wool of mixed qualities at the lamb stages makes classing of wool at a later stage difficult. The result is that it fetches lower price to the producers facilities for classing of wool at the shearing centres and in important markets will help the producers in a big way.

Quality of indigenous and exotic wool

Direct comparison of the quality of wool produced in India and other countries is not possible since they vary significantly in quality and type. The indigenous wool is coarser and of mixed type which is suitable for making blankets, carpets, druggets, etc. Only few cross breeds and special breeds produce fine medium wool. Climatic and environmental factors play a distinct role in the quality of fibre obtained thus contributing significantly towards the inferior quality of Indian wool as compared to wool of other countries. Even within the country, the best type of wool is usually produced in the hilly ranges with cold and dry climate. The fineness of Indian wool varies from breed to breed and from season to season. Normally, the fibres of coarse wool are longer than the fine wool and as such, the Indian wool is longer than the wool obtained from cross breeds.

The Indian wool in general, is having low crimp or no crimp at all. Bilateral cortical structure of fine wool contributes to the crimpness, which is lacking in Indian wool. Fine Merino wool is not having medulla while most of the Indian non-medullated wools have lower extension compared to Merino wools. Indian wool absorbs less moisture at a given humidity than the Merino wools.

Higher differential frictional effect (DEF) and elasticity give rise to the felting property of wool. The reticulate scaly structure and low elasticity of Indian wool with the exception of wool obtained from cross breeds result in poor felting property as compare to Merino and other wools.

The non-medullated Indian wool exhibits a different stress-stain relationship in water as compared to Merino wool. The permanent set (extent of stretch retained when released in boiling water for one hour) is lower in comparison to Merino wool.

The yield of clean dry wool is higher in the case of Indian wool than Merino wool. The Indian wool has lesser grease content, higher suint content, lower sulphur content and high lanthanide content than Merino wool. Canary coloration of Indian wool is a permanent unscourable yellow discoloration of wool as observed in wool of other hot and humid countries also like North Mexico, South Africa and Australia. The main cause of canary colouration in wool is attributed to the entry of suint

pigments into wool fibre whenever the grease content of wool is too low to act as a barrier. This is a serious drawback of Indian wool. Indian wool have indifferent dyeing properties as compared to Merino wool.

Marketing of wool

The North Temperate Zone produces 3.09 million kg, North Western dry zone 23.0 million kg Southern and coastal zone, and 7.22 million kg and East zone 1.4 million kg wool. Southern sheep are mutton type. The shepherd sells his wool to local village trader or takes the wool to marketing centre or sells to the federation. Most of the wool is sold through wool commission agents @ 1.5% commission. The Krishi Upaj Mandi tax, on raw wool is 4 % and 2% on woollen yarn. The wool price has increased from ₹ 1,450/- per quintal in 78-79 to ₹ 6,400/- per quintal in 2004-05 in Beawar. There is demand of Indian carpets overseas. Approximately 5.0 million square metre carpets are being produced each year. The export of wool and woollen textile in 1995-96 was 62.5 million dollars and in 2000-01, 63.80 million dollars The demand of carpet wool is acute and the shortage of wool is due to higher demand to the carpet wool in the country. India imported 2,465 tonnes New Zealand wool in April- June 2004. During the same period India imported 21 172 tonnes of wool from different countries.

Processing of wool

Washing: Dirty wool collected from unwashed sheep is washed with clean water. For this purpose, a stream of water as that obtained from Persian Wheel or a Tube well is preferred. Baskets full of wool are placed below the flow and trampled by foot to remove the impurities from the fibre. In some places, wool is placed in pans made of bamboo and then trampled with foot. After washing the wool is dried on pucca floor and then brought to the godowns for further processing. From then onwards the actual processing begins. The processes involved are sorting scouring, carbonizing, oiling, carding, combing, dyeing and finishing.

Sorting: Sorting of wool is the most important process and all further process are dependent on it. Sorting is a process to open up the fleece into different sub sorts as per the requirements. Women and child labour mostly do sorting of wool. Though sorting differs from market to market, it is generally done to sort out;

1. Sweaty and non-sweaty wool
2. Coarse and fine wool
3. Sorting of wool according to different colours

Scouring: Scouring is the process by which the impurities of wool are

removed. Impurities of wool may be either natural, acquired, or applied. The natural impurities arise out of oils and fats secreted by the sebaceous glands and water insoluble salts from the skin. 'Acquired impurities are sand, dirt, burrs and other forms of vegetable matter. Applied impurities observed are usually tar/pitch and paint used in some quantities for animal identification purposes or chemicals used in the treatment of sheep. Scouring is basically aimed at removing one or all of the above impurities depending on the condition of the wool and is carried out either by adopting aqueous scouring process or by solvent decreasing process.

Carbonising: Carbonising is a chemical process in the removal of burrs which creates difficulty in the manufacturing process. Acids such as sulphuric or hydrochloric or salt such as aluminium chloride is used. Burrs are also removed either by cutting them from the fibres with scissors or by heating the wool on a slab of stone with a flat iron rod and wooden bat.

Oiling: Oiling is the lubrication of the wool to minimise the breakage of wool, fibres during carding, reduction of by waste and static electricity in carding and increase cohesion of the fibres in loose silver to facilitate drafting and spinning.

Carding: Carding is carried out to further open the wool, disentangle locks, straighten the individual fibres, remove the natural impurities, further mix the stock and deliver it in a convenient form for transfer to the spanning frame.

Combing: In the process of combing, the short fibres, vegetable matter, slubs and neps are removed and these are paralleled.

Mixing: To prepare a particular type merchant carries out mixing of wool of different qualities. It is responded that wool of the same or identical quality are mixed together to form a particular standard. In mixing the wools, two important factors are kept in mind.. One is the yield and the other the average price of wool. High yielding coarse wool are usually mixed with low yielding superior quality wool to make up the yield. Some times pulled and/or carded wool is mixed and in exceptional cases ginned and limed' wool.

Canning: Canning of wool is done with the object of removing impurities like dust, dirt etc., homogenising the various qualities already mixed and producing fullfilness thereby giving it good appearance

Dyeing: Various dyes such as acid dyes, metal complex dyes are in use. Wool can be dyed in loose stock, top yarn and piece goods.

Finishing: It is the last stage, which is necessary to improve the cloth

received from the loom to suit the needs of the consumers There are various sub-processes in actual finishing. They are milling, raising, shearing, lusturing, moth proofing, shrink proofing etc.

Processing losses

It is estimated that normally 2-4 per cent of the produce is lost/ wa6ted during processing.

Cost of processing

It is also estimated that the cost of processing ranges from ₹ 1 to ₹ 2.50 The cost varies from state to state.

Effect of processing in improving the quality of wool

Utmost care is to be taken in the processing of wool to remove the natural impurities and avoid acquired impurities. As the term implies, natural impurities are not man-made and every measure should be taken to remove it. The acquired impurities like sand, dirt, burrs and other forms of vegetable matter can be avoided, if proper care is taken at the time of shearing, collection, transportation and processing. If the wool is not collected properly, it will fetch low price. By various processing techniques, the intrinsic value of the wool is increased. Various foreign matters like dust etc. are removed and the commodity reaches the consumer in the form he desires. The various processing activities also help in the storage, as well as transportation of wool.

Packing: The final stage in the preparation of wool for market is packing in big gunny bags or boras or pallas.

Bailing: Wool being a fluffy and light material, occupies a large volume and considerable expenditure has to be incurred during transport, handling as also on account of freight. In order to avoid these expenses, wool meant for export and for distant markets within the country is pressed into rectangular hales at the bailing presses. These bales have gunny coverings and retied with iron hooves. The size and weight of the bales vary from place to place.

Canary Colouration of Wool

Incidences of canary colouration increase with the increase in atmospheric temperature and humidity (Nagarcenkar, 1961; Narayan and Sharma, 1970). This problem is more in Gujarat, Haryana, Punjab, Uttar Pradesh and Rajasthan. Sheep of this region produce 12.6 million kg wool according to 2003 Animal census, which is 57 per cent of the total wool produced in India. Canary coloration varies from 80-100 per

cent in autumn clip (Narayan, 1969). Canary colouration reduces the income from wool to sheep farmers Such wools do not take up colours properly. Yellowing of wool starts with the onset of rainy season. It is more in breeds, which produce more wool.

Yellowing is more in growing lambs as compared to adult sheep (Narayan and Sharma, 1970). Canary colouration starts decreasing after three years of age (Narayan, 1969). It is more in rams than in ewes (Narayan and Sharma, 1970). The quantity of canary colouration varies from region to region of the body. It starts from legs and spreads to other parts of the body.

There are more incidences of canary coloration of wool in Romney marsh than in Corriedale sheep in New Zealand (Henderson, 1965). It is more in Marwari breed than in Malpura breed (Narayan, 1969). It is less in coarse and less crimpy wool (Kapoor *et al.,* 1972). Canary colouration is of two types (Serra and deMatos, 1951).

Simple canary colouration: It goes with the washing of wool. It does not harm wool.

Special canary colouration: It does not go with simple washing. Such wool does not take different colours permanently.

Causes of canary colouration of wool

Light: Sun light does not cause yellowing of wool (Nagarcenkar, 1964). Less yellowing is observed in Chokla sheep, which are grazed between 8 PM and 5 AM as compared to those grazed during day (Anon, 1972a). White wool becomes yellow on keeping in sun light. It also becomes yellow if kept in ultra violet rays.

Climate: It is well known fact that yellowing of wool starts with the onset of rainy season when the atmospheric temperature and humidity are high. It starts from the month of June when the atmospheric temperature is 43.1°C and relative humidity 57 per cent (Anon, 1972a). Wool becomes yellow if kept at pH 3.0 at 38°C for 1-2 weeks (Serra and De Matos, 1951). It becomes yellow if kept in alkaline solution at 150°C (Norton and Nicholls, 1960).

Hereditary: Yellowing is found more in some breeds than in otheRs It is found in Chokla, Hissar dale, Sonadi, Malpura, Jaisalmeri, Marwari, Magra in decreasing order (Narayan and Sharma, 1970). It has been found in decreasing order in Marwari, Chokla, Rambouillet × Chokla (50%) (Anon, 1972b). No difference has been observed between Bellary and Bikaneri in this respect (Nagarcenkar, 1963, 1964; Nagarcenkar and Bohra, 1983).

Table 10.9 Amount of wool wax found in different breeds of sheep.

Breed	Per cent of wool	Breed	Per cent of wool
Sonadi	4.37	R x M (50%)	10.73
Malpura(M)	4.74	R x M (75%)	11.43
Jaisalmeri (J)	5.60	R x C (50%)	13.38
Pugal	6.05	R x C	14.05
Chokla(C}	8.71	R x C (75%)	18.10
Nali	9.63	Russian Merino	19.10
Magra	7.25	Rarnbouillet (R)	22.32

Wool wax: It is more in wool in colder months and is more in fine wool breeds (Sutton, 1935). If the quantity of wool wax is more in wool, it does not become yellow (Chippalkatti *et al.,* 1965). The amount of wool wax differs with the breed (Anon, 1972a), (Table 10.9).

Wool wax was found more in spring clip of Nali breed (Chippalkatti *et al.,* 1965; Narayan and Sharma, 1970).

Microorganisms: Colour producing microorganisms develop in hot humid climate (Fraser and Mulcock, 1956).

Green fodder: Yellowing of wool develops in season when there is more green fodder available. Green colour of green fodder is not absorbed through intestine so there is less probability of yellowing due to it.

Remedies

Different measures have been adopted at times to reduce yellowing of wool. Some of them are:

Changing the time of shearing: Normally the sheep are shorn in March and September. If they are shorn at the time when the yellowing starts, white wool can be prevented from yellowing (Narayan, 1969). So they should be shorn in the beginning of rainy season.

Washing of wool: Weekly washing of Chokla sheep reduces canary colouration to negligible amount (Narayan and Sharma, 1970).

Cross breeding: Yellowing of wool is found to be reduced in crossbred sheep.

Energy: Sheep should be given dry fodder during summer season to reduce sweating.

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Pelt Production

Karakul is the only breed of sheep known for its quality pelts. The Karakul pelts are most priced because of their unique beauty of curl patterns and diversity in colour. Karakul pelts are obtained by sacrificing neonatal lambs. The nature of their hair, the histo-structure of the collagen formation and state of hair follicles display a number of specific features in the pelts.

The Karakul pelts are one of the ancient fur used by man. In the past, the Central Asian merchants maintained a brisk trade among themselves; a part of these was exported to Western Europe and the Middle East through Iran. During the middle of the 19th century, Russia imported an annual average of 1.4 million Karakul pelts from Bukhara. In recent times, Karakul sheep breeding is concentrated mainly in two parts of the world, the Republics of Central Asia especially Kazakhstan and the neighboring regions of Afghanistan and also in Namibia and the Republic of South Africa.

Tracing back the history of Karakul sheep breeding and the use of pe1ts, the 'curl lambs' were produced about 900 years ago by the nomads of that time who used these skins for clothing and headgears. Kyleshov (1947) considered Karakul as an ancient breed, which was contrary to Adametz (1936) who considered this breed as having a comparatively recent mutation of fur cover. Karakul sheep were brought in Bukhara when the Arabs invaded Central Asia in the 8th Century and were retained later by the Mongols. However, Perepelkin (1915), Vasin (1944) and Averyanov (1968) considered that Karakul breed has been evolved as a result of crossbreeding. Great variability in body form, size, wool production and quality of adult animals, the kink and crimp of fur in lambs and the shape of the tail etc. of Karakul point to the origin of Karakul as a result of crossbreeding.

Odintsova (1965) on the basis of historical facts concluded that the Karakul breed was evolved in the desert of Middle Asia in the later part of 18th and early 19th century. The initial stock used for creation of Karakul breed was multipurpose sheep in Middle Asia, which produced mutton, wool, milk and also a low quality skin as a by-product. The

economic basis of the creation of Karakul breed was the formation of world market, the growth of urban population in Europe with an increased demand for furs and pelts and a corresponding decrease in number of hand-craftsmen in the Middle Asian towns. The opinion of the authors differ about the origin of Karakul but it appears that this breed has been evolved comparatively recently, perhaps in the 19th century in the Republic of Uzbekistan as a result of cross breeding with the local fat tailed sheep as one of their ancestors (Honmode, 1975). In USSR, the Karakul breed is known to have developed in the most trying desert conditions. The sheep of this breed are well adapted to sparse pasture conditions in arid zones, have good thermo-regulatory mechanism, have very mobile lips for close grazing, endure fasts well and are capable of utilizing their fat deposits, particularly in the tail during trying times.

The northwestern arid region of India has certain agro-climatic conditions common to the home tract of Karakul sheep. These areas in Kazakhstan and Central Asia have very low precipitation (80 to 200 mm annually), evaporation factor is very high and exceeds the amount of precipitation by 4 to 12 times. Daily and seasonal temperatures fluctuate over a wide range from -12 to –140° C in January to 23 to 29° C in July. The vegetation is sparse and has low yield from 1.5 quintals of air dry edible mass per hectare with considerable annual and seasonal fluctuations (Abedramov and Safonov, 1975). The arid regions in India have an erratic annual rainfall ranging between 100 to 500 mm with maximum temperature as high as 49° C during summer and minimum temperature falls to the level of –20° C during winter months. There is fast evaporation and even large potential evapotranspiration (1,600 to 2,000 mm). The soil is coarse textured and has poor fertility status, low moisture retentively and poor vegetation cover.

Breeding sheep for pelt production in the region with extremes of climates and highly seasonal feed resources will be desirable, as it will cut down on the mortality of young lambs. Majority of male lambs, which are not required for breeding and weakling females, can be sacrificed at birth for pelt production. It will also allow availability of milk from such ewes whose lambs have been slaughtered, either for rearing orphan lambs or for human consumption.

The Karakul breed is quite close to coarse carpet wool breeds of semi-arid and arid regions of India in wool quality and both of these possess qualities of great adaptability, endurance and stability under severe and adverse conditions of arid climate with scanty and sparse vegetation. Further, it has the valuable pelt possessing specific types of

curls with silky feel and bright luster. All this led to formation of programmes for its crossbreeding with the coarse indigenous carpet wool breeds, viz., Malpura, Marwari and Sonadi.

Sheep in India have traditionally been kept for wool, mutton, skins, and manure and to some extent for milk. There has been little emphasis on lamb pelt production, although it is known that the khatik community in Rajasthan does produce lamb pelts from Malpura breed on a small scale. An attempt is now being made to add this new dimension to sheep products industry in India.

Fur apparel is considered as a status symbol in many countries. Besides being an item of luxury, wearing of fur garments and other outfits made of fur skins/furlings make the living during winter comfortable. Naturally, fairly large concentration of the industry in India is in the Kashmir valley and to certain extent, in the Rajasthan and other Northern regions. In addition to meeting local needs, properly dressed finished furs have great export potential and the value added to raw furs through such processing is manifolds. The industry in India, however, has so long remained traditional and primitive possibly due to insufficient availability of raw skins and lack of modernisation of the processing.

Importance of lamb pelt production

Lamb pelt production is an important facet of sheep industry in a number of countries, especially, USSR, Afghanistan and South Africa. Karakul is an important breed for producing lamb pelts. It is a fat tailed, coarse carpet wool breed, very well adapted to extreme climatic conditions and poor vegetation resources.

Karakul sheep population in Asia and Africa is around 31.5 million, which is around 7.5 per cent of the total sheep population in this region. The Soviet Union, with an annual production of ten million pelts, is still the leading producer, followed by South Africa, with about 5.5 million pelts per annum. The pelts are produced either through the slaughter of lambs within 24-48 hours of birth or through killing of unborn lamb removed through slaughter or through abortion of the mother around 130- 140 days of pregnancy. The latter type of pelts known as fat tailed Persian, are twice more valuable than the best types produced from slaughter after birth as they have better ornament, are lighter and more lustrous. The lamb pelts sell between $ 15 to 20 per pelt in international market depending upon the size and quality.

The type of curls, their size and tightness and lustre generally determines the quality of pelt. The size and weight of pelt are also important factors in deciding the quality. The curls are usually termed, as long when the length of hair is more than 20 mm. Present trends is

to get light pelts with short hairs. The size of curl is completed during foetal life itself. The pelts are classified into various types such as Jacket, Ribbed, Flat and Caucasian. The pelts are classified into five different types on the basis of their ornamental value as describe in Table 11.1.

Table 11.1. Types of pelts and their characteristics

Grade	Type	Characters
Grade 1.	Jacket:	Most valuable type and is characterized by the presence of semicircular pipes or pipe curls of medium size
Grade 2.	Caucasian:	Characterized by the presence of predominantly walnut curls
Grade 3	Ribbed:	It shows narrow feathery and small pipes arranged horizontally and parallel to the ribs on the body of lamb
Grade 4.	Flat:	Characterized by the presence of lustrous but flat hairs lacking curliness. The broad feathery curls are dominant on the body.
Grade 5.	Rejects:	It has hair cover with majority of small bean shaped curls, rings, ring lets, corkscrew type hairs. These have no ornamental value and hence are undesirable

Flock management

All the sheep were maintained on free range grazing on native pasture which consisted primarily of annual grasses such as *Aristida funcunilata* (*Lampla*) and *Cenchrus biflorus (Bharbhut/Bhurath*); perennial grasses such as *Lasiurus sindicus* (*Sewan*), *Dactyloctenium sindicum* (*Ganthia*), *Elusine compressa* (*Tantia*) and Cenchrus spp.(*Anjan*); legumes like *Indigofera spp,-* (*Bakaria*), *Tephrosia purpurea* and *Tribulus terrestris* (*Gokhru*), and trees and shrubs like *Prosopis cineraria* (*Khejri*), *Zizyphus nummularia* (*Pala*), *Calligonoum polygonoides* (*Phog*), *Aerva pseudotomentosa, Crotolaria burhea* and *Cymbopogan* spp. About 474 hectares of natural grassland having productivity of approximately 400–700 kg/hectare of dry matter was available for grazing of the Karakul and crossbred sheep. In the earlier years of establishment no supplementation, either with cultivated fodder or grains was provided. However, in subsequent years, supplementary feeding to the advanced pregnant and lactating ewes and young lambs was provided. Green fodder such as *Avena sativa* (Oats) and *Pennisetum typhoides* (*Bajra*) were fed to the flocks according to their availability and dry hay was supplemented particularly during February to June when the grazing resource available in the pasture was depleted. The animals were allowed

to graze from 0800 to 1700 hr daily except during the summer months from April to June when split grazing during cooler hours of the day was observed from 0600 to 1200 and 1500 to 1900 hr. The schedule for supplementary feeding of concentrate to various categories of sheep in the project is presented in Table 11.2 along with details of the composition of concentrate mixture/pellets in Table 11.3.

Table 11.2. Schedule of supplementary feeding of concentrate

Class of animal	Rate / Animal/ Day (g)	Period
A. Exotic and three-fourths		
Rams	500	120 days (Prior to and during breeding season)
	400	180 days (Lean period February to July)
	300	90 days (Lean period November to January)
Ewes	400	During advance pregnancy and lactation
Lambs and Hoggets		
I. 15-90 days age	*ad lib*	75 days
II. 91-180 days age	400	90 days
III. 181-360 days age	300	180 day
B.Native and half-bred		
Rams	300	180 days (breeding season and lean period)
Ewes	300	120 days (Advance pregnancy and lactation)
Lambs and Hoggets		
I 15-90 days	*ad lib*	75 days
II 91-180 days	300	90 days
III. 181-360 days	250	180 days

Table 11.3. Composition of concentrate mixture/ Pellets

Constituents	Lamb ration (up to 90 days)	Adult ration
Ground Maize/Barley	67 parts	50 Parts
Wheat bran	10 parts	17 parts
Ground nut cake	10 parts	30 parts
Fish meal	10 parts	
Mineral mixture	2 parts	2 parts
Salt	1 part	1 part
Vitamin A and B-5	25 g/quintal	
Antibiotic feed Supplement TM-5	150 g/quintal	

The sheep were housed during the night in sheds covered with asbestos sheets with open sides during winter and in open corrals made by chain link fencing during summer months. An area of about 1.5 square meters per sheep was provided. The animals were watered both in morning and evening at the sheds/open corrals. The supplementary feeding of concentrate was done in the evening hours and stall feeding of green/hay during the period the animals were housed in sheds/open corrals.

The breeding season generally commenced towards the end of August continued up to beginning of November. The ewes in heat detected both in the mornings and evenings by teaser rams. Ewes showing estrus were hand mated randomly to breeding rams only once during the estrus cycle and their identification number was noted. Repeat breeders were again mated to rams in subsequent cycle randomly. The mating was continued for three estrus cycle, The shearing of animals was done in April/May and October/November either with machine or hand shears. The first shearing was done at the age of approx. 6 months. The sheep were given a dip in clean water before shearing.

The newborn lambs were kept with their respective dams for the first 3 days in a separate pen. The dams were thereafter sent for grazing and the lambs were allowed suckling thrice a day up to 30 days and twice a day up to 90 days of age. Lambs were weaned from their mothers at the age of 90 days. The lambs of both the sexes were kept together up to the age of 180 days after which these were separated and reared in separate flocks under uniform environmental conditions. The surplus lambs were slaughtered within 24 to 48 hours of birth to obtain pelts.

Breeding sheep for pelt production

The development of an appropriate organisation for undertaking development programmes is also an area, which needs serious consideration. Since majority of people involved in sheep and wool production belong to the class of rural poor, with a little land or no land, it is necessary that programmes are organised not only to provide institutional finance for establishment of animal unit with them but also to provide finances for other inputs preferably providing them as a package of development agency, providing remunerative prices through a properly organised marketing system and development of animal fibre/ wool based handicraft in the area of production. It is only through such programmes organised on cooperative basis involving the beneficiaries, a large number of rural population can attain remunerative self-employment.

Karakul sheep breeding for pelt production offers a good promise, because the experimentation done so far indicate that the crossing of Karakul with coarse carpet wool and meat type breeds give excellent pelt quality at 50% and 75% exotic inheritance levels.

Fertility of ewes

The Karakul ewes in the farms of Central Asia and Kazakhstan as a rule give birth to one lamb at a time. Percentage of twins depends upon nutritional and better management conditions and varies between 2 to 10%. In some farms in Ukraine and Astrakhan, the twining percentage goes upto 40%. However, Karakul ewe has a potential for producing more lambs through super ovulation caused by the use of pregnant mare serum gonadotropin (PMSG). PMSG is used abundantly for augmenting Karakul pelt production in the Soviet Union and about 4 million sheep are treated with PMSG every year.

Because the Karakul lambs are slaughtered in the early stages of their life, super ovulation by the use of PMSG becomes interesting proposal. In USSR, 150 to 170 lambs per 100 ewes are produced in some farms by this method.

The early slaughter of lamb eliminates mortality in weakling lambs. The mothers whose lambs have been slaughtered may be rebred and thus can produce lambs more often. Karakul sheep produces milk also, particularly because the mother is without her lamb immediately after lambing; they are milked in many farms, where flocks are in well fed condition. There, they give about 25-30 kg milk in one lactation with fat percentage from 5 to 7%. Their milk can be used as foster mothers for twin lambs or which have lost their mothers or their mothers have very poor milk production. The further elimination of a large number of lambs at birth will reduce the pressure on feed/fodder resources as for meat/wool they must be reared for a longer period.

The wool, mutton, skins, manure and milk will also be available from the flocks being reared for pelt production, thus pelt production will replace only the disposal of extra male lambs which would normally have been marketed for meat around 9 months to one year of age.

The Karakul sheep have shown adaptation to hot arid conditions. The greasy fleece weight of six monthly fleeces has been observed to be 1.23 and 0.90 kg in case of rams and ewes, respectively. Among the native breeds, Malpura produced pelts of best quality followed in descending order by Sonadi, Nali and Chokla (Table 11.4). The ornamentation in native breeds is restricted to the part of skin, whereas in case of Karakul, it is spread over whole of the skin. In case of Chokla

Table 11.4. Distribution of Karakul pelt types in Malpura, Sonadi and their crosses

Breed and breed crosses	Number	Jacket %	Ribbed %	Flat %	Caucasian %	No class %
Malpura	39	10.00 (4)	52.50 (20)	27.50 (11)	5.00 (2)	5.00 (2)
Karakul x Malpura (halfbreds)	11	36.36 (4)	45.45 (5)	18.18 (2)	Nil	Nil
Sonadi	50	22.00 (1)	22.00 (11)	38.00 (15)	8.00 (4)	27.00 (18)
Karakul x Sonadi (halfbreds)	24	41.67 (10)	33.33 (8)	20.83 (5)	4.17 (1)	Nil

NB: Figures within parentheses indicate the number of observations

and Nali and majority of crosses, for evolving fine wool breeds, largest percentage is of ribbed type.

About 80% Karakul in the USSR are black. The remaining 20% could be grey, brick sur, or rose colours. These coloured Karakuls are less adaptive to harsh climate and nutrition. The pelts produced by crossing native sheep may be black, brown, black on white or white on brown in colour.

Quality evaluation of pelts

The generalizations and broad principles deducted by Ivanov and Yudin (1932) and Dhillon (1980) after investigations, a great mass of material provided the basis of development of systematic evaluation methods. The composition and properties of a Karakul pelt determine, its commercial value. As the most important component of a Karakul pelt is its specific curls, the quality of the pelt, by and large, depends upon the quality of its curls. The absence of curls or curls of low quality may diminish the value, of the pelt. Besides, there are a number of other properties, which influence the quality of the pelt. The chief of these attributes are:

1. Curls kind, size and patterns.
2. The coloration of the hair coverings.
3. The quality of hair, silkiness, gloss, density, tightness, elasticity.
4. The size of pelt.
5. The weight of pelt.
6. The thickness of the skin.

Distribution of Karakul pelt types in Malpura, Sonadi and their crosses is given in Table 11.4 and 11.5.

Classification of curls

Karakul curls are classified into different types according to their size and shape as detailed below.

Pipes and Beans: These are the most valuable curls characterizing the first grade pelts of Jacket and Ribbed types.

Walnut curls: The pelts belonging to the first and second grades of Caucasian group show the predominance of walnut curls.

Feather curls: The second grade pelts of flat type are characterized by the presence of these curls. Feather curls are less valuable.

Corkscrews, rings, etc: These are faulty and defective curls and hence undesirable.

Table 11.5. Distribution of Karakul pelt types in Malpura, Sonadi and their crosses with Karakul on the basis of their fiber length

Breed/ Breed crosses	Jacket								Ribbed							
	I		II		III		Overall		I		II		III		Overall	
	% age	Fibre length (mm)	% age	Fibre length (mm)	% age	Fibre length (mm)	% age	Fibre length (mm)	% age	Fibre length (mm)	% age	Fibre length (mm)	% age	Fibre length (mm)	% age	Fibre length (mm)
Malpura	1.66	9.00	2.50	8.00	0.83	8.00	5.00	8.33	3.32	8.75	17.5	9.95	19.17	12.00	40.00	10.83
	(2)	(2)	(3)	(3)	(1)	(1)	(6)	(6)	(4)	(4)	(21)	(21)	(23)	(23)	(48)	(48)
Sonadi	-		0.65	-	0.65	14.00	1.31	14.00(I)	-	-	6.58	12.77	89(12)	12.33	14.47	12.49
			(1)		(1)	(1)	(2)				(10)	(10)		(12)	(22)	(22)
Karakul x Malpura (1/2)	17.02	6.46	10.63	10.40	2.12	9.00	29.78	8.05	21.28	7.56	14.89	8.74	–	–	36.17	7.76
	(8)	(8)	(5)	(5)	(1)	(1)	(14)	(14)	(10)	(10)	(7)	(7)	–	–	(17)	(17)
Karakul x Sonadi (1/2)	16.17	7.03	22.06	8.56	4.41	8.33	42.64	7.95	16.17	7.55	8.82	8.33	7.35	12.20	32.34	8.81
	(11)	(11)	(15)	(15)	(3)	(3)	(29)	(29)	(11)	(11)	(6)	(6)	(5)	(5)	(22)	(22)
Malpura	3.32	10.25	10.83	9.85	14.17	11.9	28.33	10.97	–	–	0.83	11.00	1.66	15.5	2.50	14.0
	(4)	(4)	(13)	(13)	(17)	(17)	(34)	(34)			(I)	(1)	(2)	(2)	(3)	(3)
Sonadi	3.29	9.6	9.87	12.0	10.92	14.25	23.68	12.64	–	–	1.31	12.00	1.31	12.50	2.62	12.25
	(5)	(5)	(15)	(15)	(16)	(16)	(36)	(36)			(2)	(2)	(2)	(2)	(4)	(4)
Karakul x Malpura(1/2)	10.64	8.40	12.76	9.33	4.25	9.00	27.66	8.92	4.25	10.00	2.12	9.00	-	-	6.38	9.67
	(5)	(5)	(5)	(6)	(2)	(2)	(13)	(13)	(2)	(2)	(1)	(1)			(3)	(3)
Karakul x Sonadi (1/2)	19.11	7.99	7.35	9.20	1.47	10.00	27.94	8.42	5.88	8.25	5.88	10.25	–	–	11.76	9.37
	(13)	(13)	(5)	(5)	(11)	(1)	(19)	(19)	(4)	(4)	(4)	(4)			(8)	(8)

N.B.Figures in parenthesis indicate the number of observations

Advantages of pelt production

Good quality carpets can be made from the sheep produced by crossing native sheep with Karakul rams. As the lambs are used for pelt production immediately after birth, so lamb mortality is reduced to zero. The sheep whose lambs have been used for pelt production, produce two lambs in a year or three lambs in two years, can be used for milk production. The expenditure on fodder, concentrate, and health, shelter for such lambs is eliminated and meat of these can be used as protein supplement in feeds.

Pelt making

The pelts are produced either through slaughter of the lamb after birth (within 12-24 hours of birth) or through killing of an unborn lamb acquired by slaughter of the dam or its abortion at around 130 to 140 days of pregnancy. The latter pelts are known as broad tail (fat) Persian pelts and are twice more valuable than the best type produced through the post-natal slaughter of the lamb. The quality of the pelt is determined by its ornament i.e. type of the curls, their size and tightness, lustre and pelt weight.

To make profits from pelt production, the pelt must be removed within 24 hours of birth. This should be allowed to cool on wooden board. Then meat, if any, sticking to pelt, should be removed and finely ground salt applied. It is then dried in shade. In the end excess salt is removed with a soft brush. Such pelt can be preserved upto six months.

Performance of karkul crossbreds

The Karakuls combined well with the coarse carpet wool breeds (Malpura and Sonadi) as the crosses with Chokla and Nali were much inferior in pelt quality as compared to the crosses with Malpura and Sonadi.

Malpura lambs produce better pelts as compared to Sonadi. The ornament in the native breeds are restricted to only part of the skin, it is spread over whole of the skin in Karakuls. For Malpura, 5.0, 40.0, 28.3 and 2.5% pelts are of jacket, ribbed, flat and caucasian types as compared to 1.3, 14.5, 23.7 and 2.6%, respectively in Sonadi. In general the half-breds produce better types of pelts than their purebred native contemporaries, the Sonadi × Karakul half-breds produce even better types of pelts than the Malpura half-breeds. The jacket type pelts increased from 1.3% in Sonadi to 42.6% in Karakul × Sonadi halfbreds, whereas in the Malpura half-breds, the jacket type pelts are 29.8% as against 5% in Malpura. There is also improvement in luster of half-

breeds. The colour varies from patches of black or sur to complete black or sur, offering a future potential for number of colour lines.

The Karakul sheep imported between 1908 and 1914 in South Africa is the result of a crossbred base through grading up of suitable sheep, viz. indigenous Africander and Blackhead Persian breeds, adapted to unfavorable climatic conditions. Such an adventure would be profitable especially during drought periods in the arid and semi-arid areas of Rajasthan.

Leather

Leather is all important byproduct of sheep industry. Skins from sheep and goats are the basic raw material for the leather industry in addition to hides from cattle and buffaloes. Approximately 90% of the skins of sheep and goats are generally recovered from the sources of slaughter. About 30 million pieces of skins are reported to be available from sheep. FAG (1993) figures indicate that 39,780 MT of skins arc available from sheep. There is about 500% value addition when the raw skins are marketed after processing and finishing. The estimated raw material cost of the skins available from sheep is about s 3,750 million and the value addition of finished leather is estimated at s 7,500 million whereas as leather product itself is s 18,770 million. The total estimated export through leather, footwear component footwear, leather garments, and leather goods etc., prepared from sheepskins is s 9,900 million. Contribution of sheep and goats 10 the total export earning as per the 1992-93 figure is s 37,590 million, which is 65% of the total export earning through leather.

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12.
Mutton Production

Most of the breeds of sheep of tropical regions, respond poorly to better nutrition, but Iranian sheep respond quite well to improved nutrition (Demiruren *et al.,* 1971). Sheep and goat have made great contribution to meat production in India, the reason being religious taboo against eating cow and pig meat. In India sheep are mainly reared for wool and mutton production. The sheep rearing is in the hands of landless and poor people. Most of the meat sold in the market is from old sheep or male lambs. The average, market weight of native male lambs varies from 13-16 kg (Kaushish, 1980). The mutton from old sheep contains large proportion of bones. Average mutton production per sheep is much less in India as compared to some western breeds. This is because our sheep farmers are illiterate, orthodox and economically backward and decrease in pasture area for grazing sheep.

The country possesses 68.0% of world cattle and buffalo population and 23.53% of sheep and goat population and ranks first with respect to cattle, buffaloes and goats population and fifth in sheep. But the protein supply to vast human population is only 9.5 g as against the world average of 24.60 and Asian average of 15.70 g (Table 12.1). Due to lack of focused developmental efforts for improvement they at present have very low production compared to their recorded potential and exotic counterparts. On an average an Indian gets only 5.00 kg meat annually as against 11.00 kg of recommended intake. By 2010 it is estimated that to meet the requirement of 70.0% non-vegetarian population, country would require producing 7.70 million tonnes of meat.

Mutton production

About 32% of the total sheep population is slaughtered every year for mutton purposes. Thus the total mutton production is related to the sheep population in the country. During last 4 decades there has been 0.5% increase in sheep population. Further there has been increase in carcass from 10 to 12 kg. The mutton production was about 130 m kg in early 80's and about 170 m kg in early 90's constituting hardly 2% of the total meat production from sheep in the world. The mutton

Table 12.1. India's livestock population (in million) in relation to world and animal protein supply (per capita per day)

Species	World	Asia	India	%World	%Asia	Rank in World
Cattle	1,288.0	410.0	193.0	15.00	47.00	1
Buffaloe	149.0	1,44.0	79.0	53.02	54.86	1
Sheep	1,087.0	340.0	45.0	4.14	13.25	5
Goat	609.0	373.0	118.0	19.40	31.63	—
Pig	875.0	483.0	12.0	1.40	2.48	—
Total	4,008.0	1,750.0	447.0	11.15	25.54	—
Meat Production (in million tonnes)	195.0	68.10	4.12	2.11	6.05	—
Animal protein supply (g)	24.60	15.70	9.50	—	—	—

produced in different countries of the world is given in Table 12.2. However, the export of mutton from India has increased from 2 m kg in 1987-88 to 3.6 m kg in 1993-94. There is a possibility of further increase in the export of mutton future amounting to about 7.8 m kg by 2000 AD.

The consumption and production of meat in India are given in Table 12.3 and Table 12.4. According to latest census, the estimated production of meat is 582,000 tonnes as against an estimated requirement of 10 million tonnes calculated on the basis of 50.7 g per day.

Table 12.2. World Mutton production (FAO, 2004)

Continent/Country	No. Slaughtered (1,000)		Carcass wt. Kg/animal		Mutton production (1,000)	
	1989	1999	1989	1999	1989	1999
World	464,553	497,657	15	15	6,997	7,474
Africa	**66,109**	**80,423**	**14**	**14**	**900**	**1,129**
Algeria	9,557	9,601	14	17	136	163
Angola	55	77	11	15	1	1
Benin	26	241	10	10	3	2
Botswana	108	90	14	14	2	1
Burkina faso	1,205	1,417	9	9	11	13
Burundi	102	83	12	12	1	1
Cameroon	1,183	1,400	12	12	14	17
Central African Republic	54	60	15	15	1	1
Chad	515	655	16	18	8	12
Congo Dem R	286	298	10	10	3	3

Table Contd.

Table Contd.

Continent/Country	No. Slaughtered (1,000)		Carcass wt. Kg/animal		Mutton production (1,000)	
	1989	1999	1989	1999	1989	1999
Cote Divoire	455	550	10	10	5	6
Djibouti	182	200	10	10	2	2
Egypt	2,122	2,680	24	25	52	66
Eritrea		550		10		5
Ethiopia PDR	8,173		10		82	
Ethiopia		8,140		10		81
Gabon	48	58	12	12	1	1
Gambia	-	71		11		1
Ghana	550	595	11	11	6	7
Guinea	96	136	12	12	1	2
Guinea-Bissau	59	71	10	10	1	1
Kenya	2,116	1,970	12	12	25	24
Lesotho	430	300	10	10	4	3
Liberia	65	65	10	10	1	1
Libya	1,758	4,800	15	15	26	72
Madagascar	221	255	12	12	3	3
Malawi	38	-	14	-	1	-
Mali	1,650	2,096	13	13	21	26
Mauritania	845	990	15	15	13	15
Morocco	5,567	6,350	18	19	101	120
Mozambique	62	64	12	12	1	1
Namibia	727	410	17	18	12	7
Niger	737	910	17	16	14	15
Nigeria	4,033	8,310	11	11	44	91
Rwanda	83	70	12	12	1	1
Senegal	835	1,035	14	14	12	14
Sierra Leone	94	105	11	11	1	1
Somalia	2,490	2,150	11	13	32	28
South Africa	10,101	8,500	13	12	133	103
Sudan	4,372	8,900	16	16	70	142
Tanzania	817	970	12	12	10	12
Togo	252	295	11	11	3	3
Tunisia	3,170	4,000	12	13	39	50
Uganda	473	690	14	14	7	10
Zimbabwe	42	-	14	-	1	-

Table Contd.

Table Contd.

Continent/Country	No. Slaughtered (1,000)		Carcass wt. Kg/animal		Mutton production (1,000)	
	1989	1999	1989	1999	1989	1999
N.C. America	**8,227**	**6,274**	**25**	**24**	**203**	**153**
Canada	485	492	20	21	10	11
Cuba	132	92	12	12	2	1
Guatemala	134	170	15	15	2	3
Haiti		35		17		1
Mexico	1,614	1,900	16	17	25	32
USA	**5,707**	**3,455**	**28**	**30**	**162**	**105**
South America	19,300	18,523	15	14	289	265
Argentina	4,867	3,100	17	15	85	45
Bolivia	1,760	1,763	8	9	14	15
Brazil	4,847	5,500	16	16	78	88
Chile	862	834	16	15	14	13
Columbia	568	745	15	14	8	11
Ecuador	229	440	14	14	3	6
Falk Land Is	55	46	18	18	1	1
Fr Guiana	52	52	10	10	1	1
Paraguay	181	178	15	15	3	3
Peru	2,108	2,320	10	13	21	30
Uruguay	3,655	3,400	17	15	60	57
Venezuela	122	140	13	15	2	2
Asia (FMR)	**141,943**	**214,933**	**14**	**14**	**2,056**	**3,031**
Asia		235,885		14		3,387
Afghanistan	7,087	7,300	16	16	113	117
Armenia		3,100		17		5
Azerbaijan		1,900		17		33
Bahrain	311	300	18	18	6	5
Bangladesh	218	370	7	7	2	3
China	46,021	104,200	12	12	551	1,250
Cyprus	190	154	20	28	4	4
Gaza Strip					1	1
Georgia		452		15		7
India	15,100	19,000	12	12	181	228
Indonesia	3,567	2,400	10	11	36	37
Iran	14,585	1,300	16	16	233	293

Table Contd.

Table Contd.

Continent/Country	No. Slaughtered (1,000)		Carcass wt. Kg/animal		Mutton production (1,000)	
	1989	1999	1989	1999	1989	1999
Iraq	1,417	1,150	16	16	23	18
Israel	257	250	19	20	5	5f
Jordan	569	509	16	28	9	14
Kazakhstan		6,404		18		114
Korea D P Rep	175	70	15	15	3	1
Kuwait	1,157	1,860	17	17	20	31
Kyrgystan		2,635		17		44
Lebanon	393	402	22	22	9	9
Mongolia	6,537	4,250	19	20	108	87
Myanmar	87	127	15	15	1	2
Nepal	330	320	9	9	3	3
Oman	367	428	30	30	11	13
Pakistan	10,795	15,500	17	19	189	301
Qatar	720	490	15	15	11	7
Saudi Arabia	3,562	4,000	17	18	62	70
Singapore	28		27		1	
Syria	6,507	8,650	18	18	117	156
Tajikistan		533		15		8
Thailand	45		15		1	
Turkey	19,403	20,200	16	16	305	317
Turkmenistan		4,000		15		60
United Arab Emirate	1,227	1,300	18	18	22	23
Uzbekistan		4,719		18		84
Yemen	2,124	2,298	10	10	21	23
Europe (FMR)	**98,982**	**85,827**	**14**	**15**	**1,429**	**1,255**
Europe		96,549		15		1433
Albania	973	1,286	8	9	11	12
Austria	248	298	22	22	5	7
Belarus		120		25		3
Bel-Lux	359	230	21	20	8	5
Bosnia Herzg		225		12		3
Bulgaria	4,186	2,250	16	20	66	46
Croatia		156		11		2

Table Contd.

Table Concluded

Continent/Country	No. Slaughtered (1,000)		Carcass wt. Kg/animal		Mutton production (1,000)	
	1989	1999	1989	1999	1989	1999
Czechoslovak	581		17		10	
Czech Rep		150	20	3		
Denmark	70	68	21	22	1	1‘
Faeroe Is	46	47	11	11	1	1
Finland	55	57	19	21	1	1
England	20,183	19,107	19	19	374	361
France	9,634	7,443	18	18	171	131
Germany	2,307	2,180	21	20	47	44
Greece	7,891	7,301	11	11	89	79
Hungary	358	210	17	16	6	3
Iceland	628	515	15	15	9	8
Ireland	3,650	4,230	22	21	80	88
Italy	8,894	7,220	9	9	79	68
Lithuania		57		25		1
Macedonia		295		19		6
Moldova Rep		295		12		4
Netherlands	594	635	25	25	15	16
Norway	1,218	1,216	20	20	24	24
Poland	1,765	77	16	34	28	3
Portugal	2,360	2,300	11	10	25	23
Romania	8,113	5,500	11	9	92	50
Russian Fed		9,118		17		155
Slovakia		163		9		1
Spain	19,119	20,210	11	11	216	232
Sweden	268	190	18	18	5	4
Switzerland	229	330	20	19	5	6
Ukraine		1,110		14		15
Yugoslavia		1,920		15		29
Oceania	**69,226**	**60,003**	**17**	**18**	**1,179**	**1,106**
Australia	32,090	30,147	19	20	613	608

Table12.3. Meat consumption per head in different countries

Countries	g/ day
Argentina (1963-65)	256
Australia	290
Burma (1964-66)	12
Canada (1967)	5
Ceylon (1968)	250
China (1964-66)	47
Denmark 1966	166
Germany (F.R.)	200
Hong Kong	111
India	4
Indonesia (1963-65)	11
Japan	37
New Zealand	302
Pakistan	11
Philippines	43
Sweden	145
UK	205
USA	299
USSR (1964-66)	106
Yugoslavia (1967)	85

Source: *FAO Production year book*, Vol. 23, 1969

According to 2003 census there are 61.8 million sheep in India. Despite the fact that India stands fourth with respect to sheep population in the world, there was a steady decline in its population figures between 1966 and 1977. This might be due to high percentage of slaughter of sheep for mutton production (26.2 per cent) as sheep alone contributes to 13.64 per cent of the total meat produced in the country and there is a steady increase in mutton production during the last few years.

Presently, the total meat production is little over 4 million tonnes. It is made available through about 3,000 recognized slaughterhouses in the country. It is estimated to be 20 million tonnes by the year 2010 (Narain, 1998). Total value of meat and by-products from livestock sector amounted to ₹ 172,600 million in the year 1994-95. As per FAO estimate (1994) about 47.01 million goats, 14.30 million sheep, 21.3 million bovines (cattle and buffaloes), 11.65 million pigs were slaughtered leading to extraction rate of about 40% goats, 32.0% sheep, 17.5% bovines and 97% for the pigs (Table 12.4). Sheep and goat meat

together contribute 0.64 million tonnes accounting for 15.56% to the total meat production. Although the number of goat and sheep available in country is high, the slaughter rate is very low, when compared to Europe (71% for goat, 70.0% for sheep) and even world average. As it is to be expected meat production is highly correlated with number of animals but the higher meat production in relation to animal number in Oceania and North Central America is due to higher carcass weight of sheep and goats in those regions compared to African countries and India where per cent meat production is less than percentages of animal numbers. Even if we compare among the SAARC countries, under similar agro climatic conditions and adopting similar production systems the average carcass weight in Pakistan for goat is 21.0 kg and sheep 24.0 kg as against 10.0 and 12.0 kg in India (Table 12.5). The poor productivity is mainly due to poor exploitation of genetic potential, inadequate resources of feed and fodder insufficient health cover, inadequate marketing and credit support, etc.

Table 12.4. Meat production from Sheep and Goat

Parameters	Cattle	Buffalo	Goat	Sheep	Pig	Poultry	Others
Population (million head)	193.00	79.00	118.00	45.00	12.00	467	—
No. of slaughtered (-do-)	12.54	8.73	47.01	14.30	11.65	—	—
Meat Production (MT)	1.30	1.20	0.47	0.17	0.41	0.44	0.13
Av. carcass wt.(kg)	103.00	138.00	10.00	12.00	35.00	—	—
Slaughtered (%)	6.50	11.05	39.83	31.78	97.08	—	—
Meat Production	31.36	29.22	11.41	4.15	9.95	10.67	3.16

Table 12.5. Carcass weight of small ruminants in SAARC countries

Country	Carcass wt. (kg)	
	Goat	Sheep
Bangladesh	7.0	7
Bhutan	9.0	10
India	10.0	12
Maldives	—	—
Nepal	11.0	9
Pakistan	21.0	24
Sri Lanka	20.0	7

Contribution of sheep

It is a well known fact that sheep are being reared in the country for two main purposes namely mutton and wool. As per the estimated targets by 2010 AD, we propose to raise the wool production from 36.81 million kg to 66 million kg and meat production from 1.3 million tonnes to 3.1 million tonnes, almost a 79.3 per cent and 38.5 per cent increase from the present level in wool and mutton production, respectively. Besides this the contribution of sheep to the livestock economy can be easily evaluated from figures indicated in Table 12.6.

Table 12.6. Contribution of sheep to livestock economy in relation to world production

Items (in million tonnes)	India	Per cent of world total
Meat	0.125	2.10
Wool	0.036	1.30
Skin	0.034	3.00

The number of well-defined sheep breeds available in the country is around 42 and out of these Nellore and Mandya deserve a mention with respect to meat quality. These breeds attained weight of 10.94±0.11 kg and 9.84±0.12 kg by three months time.

An average adult sheep weighs 26.0 kg and the dressing percentage is 40. About 28 percent sheep are slaughtered every year and they produce about 4.45 million kg mutton. Average mature live weight of a number of Indian breeds is given in Table 12.7. Few Indian breeds attain mature live weight of more than 40 kg. Average mature weight of Sudan Desert sheep varies from 25 to 50 kg (Osman *et al.,* 1970). Mature Awassi and Arabi weigh 42 kg and 38 kg, respectively (Asker and EI Khalisi, 1966). The sheep of many tropical breeds dress out poorly. Hejazi sheep dress out at 37 to 40 per cent and the dressing out percentage of Sudan Desert sheep varied between 36.4 and 52.1 (Osman and EI Shafie, 1967). However, Demiruren *et al.,*1971 stated that the dressing out percentages of range fed ewes and rams in Iran were 56.5 and 55.3, respectively.

Means for increasing meat production

The dressing percentage of some of our breeds like Mandia and Nellore are comparable with some of the best mutton breeds. It varies from 36.8 to 51.8 per cent. Dressing percentage is better in Malpura and Sonadi as compared to some other breeds found in India. The only solution to increase mutton production is by crossing our native breeds with exotic mutton breeds. Care was never given for mutton production

Table 12.7. Average mature live weight of some breeds of Indian sub continent

Breed	Average mature live weight (in kg)	References
Baluchi	33-34	Lall, 1947
Bellary	32-54	Kaura, 1941
Bhadarwah	32	Kaura, 1942
Bibrik	27-36	Kara, 1942
Bonpala	32-59	Katiyar *et al.,* 1981
Chokla	235	Mathur, 1977
Damani	23	Lall, 1947
Dumeri	27-32	Kaura, 1942
Deccani	20-32	Kaura, 1941
Hassan	23	Kaura, 1942
Jaisalmeri	33-36	Acharya, 1982
Jalauni	24-32	Lall, 1947
Kaghani	23	Lall, 1947
Kathiawari	27-45	Kaura, 1942
Lohi	36-69	Kaura, 1942
Magra	24-27	Acharya, 1982
Malpura	24-41	Arora *et al.,* 1975a
Mandya	29	Kaira, 1942
Marwari	30	Acharya, 1982
Nali	24-35	Arora *et al.,* 1975 c
Nellore	38-41	Kaura, 1941
Pugal	27-32	Acharya, 1982
Sonadi	21-39	Arora *et al.,* 1977
Thal	18-27	Lall, 1947
Waziri	23	Lall, 1947

in India. It was only in 1971, an All India Coordinated Research Project on sheep for mutton production was started. Following means can increase meat production:

Selective breeding of sheep: The sheep found in Northern India are heavier than those found in South India. Magra breed is one of the heavier breeds. Madras Red is heavier than the other breeds of the area. Nali and Lohi have poor conversion of concentrate into mutton. By crossing heavier rams of a breed with heavier ewes of the same breed we can increase mutton production, but the gains will be slower.

By crossing native breeds: This type of work was done in Andhra Pradesh and Tamil Nadu by crossing Bikaneri rams with local sheep. This did not give encouraging results because Bikaneri rams could not adapt themselves to hot humid climate. It was observed in Bihar that crossing of native sheep with Bikaneri rams produced heavier crossbred lambs. The ability to convert concentrate mixture into mutton varies from 14.0 to 19.8 per cent. It is highest in Nali sheep. The dressing percentage varies from 44.8 to 48.3 per cent.

By crossing native sheep with Exotic rams: Crossing of Mandya sheep with Somali and South Down rams and crossing of Nellore and Bellari sheep with Corriedale rams gave encouraging results.

It has been stated in Israel recently that Awassi X Dorset Horn crossbreds grow at a 20-30 per cent faster rate than purebred Awassi during the first 90 days of life. Ramamurti (1964) showed that both live weight and wool yield of Rommey Marsh × Nilgiri crossbreds were significantly higher than those of the indigenous Nilgiri over a four year period. Lambs produced by crossing East African Blackhead and Dorset Horn were heavier at birth and had higher growth rate than the natives (Trail and Sacker, 1966).

Marketing terminology

The marketing terminology for sheep of varying age groups is different. A sheep from birth to 12 months is termed as 'lamb', a male castrated animal between three and six months age as 'Hog' and castrated afterwards as 'Tup'. A female, which has not yet given birth to a lamb is known as 'Gimmer' and one which has given birth to a lamb as 'Ewe'.

Judging of sheep for mutton

At times it becomes difficult to judge a sheep based on the general appearance, the most deceiving factor being the covering of wool. To overcome it, we should view the sheep from a distance of at least twenty to thirty feet to assess the general breed characteristics, such as size, type of muscling, symmetry and style including the fleece growth, before handling the animal. Usually a lamb should be viewed while judging it for mutton purposes from four directions-front, top, side and rear. To be more precise ideal viewing from above directions would mean close observation about certain specific points.

Front view: The lamb should have bold muscular shoulders including arms and forearms. The animal should be free from excessive skin in throat area. Chest should be wide and clean head should be reasonably

fine (not too large) true to the breed type. Legs should be set out wide on the corners of the body.

Side view: Legs should be of average length matching with the growth, age and age at maturity. Feet and legs should be squarely placed. The animal should be neat and clean both at the rear and front.

Rear view: The lamb should be long from the hocks to the pins long in the rump area and the back should be reasonably full and leveled out over the dock. Rear legs should appear muscular, firm and full and set well apart to give a "Meat type" appearance.

Top view: The animal should give "Coke bottle view" with a reasonably clean neck blending well and should have more spring of the rear ribs when compared to the front ones, with the extra thickness spread towards the loin. The top line should be long and leveled.

After assessing the animal based on the above observations the animal should be handled to determine the degree of finish. Usually lamb buyers handle parts like backbone, ribs, edge of rack, back, hips, joints and docked tail hardness and firmness over the back and loin is a good indicator of condition of the lamb. While handling an animal it is always advisable to keep the fingers together and handle it firmly. Depth of the animal is judged by placing one hand on the top of the shoulder and another below the chest. You can run your hand on the shoulder to estimate smoothness, meatiness including muscling and degree and finish. The fullness of the shoulder is estimated just behind it. Moving the hand on the top of the shoulder, edge of the rack, back and loin including the dock can estimate smoothness, firmness and amount of finish. The width of the fore and rear ribs is estimated by using both the hands simultaneously. Following it, firmness and degree of finish of ribs can be evaluated. By grasping well the legs with both hands muscling of the leg can be assessed. Depth of the twist is judged by placing one hand on the top of the rump and other at the bottom of the twist.

In addition, if laboratory facilities are available one can also estimate the finish by estimating the rib-eye area and fat cover over the twelfth rib. According to consumer standards we consider 0.15 to 0.25 inch of fat cover and over 2.5 to 3.0 sq inch of rib eye areas as most desirable for a 25 kg weight carcass. Cameron (1992) correlated physiological responses for carcass lean content in sheep.

Carcass characteristics

Carcass traits of Malpura and Avikalin finisher lambs maintained under intensive feeding or grazing with supplementation has been

studied by Karim *et al.* (2006) and observed that loin eye area as index of muscle growth was, higher in Malpura compared to Avikalin and higher on intensive feeding than under grazing with supplementation. Solar dried citrus pulp canbe incorporated inconcentrate mixture for fattening lambs at levels equal to 30% without adverse effects both on growth and mutton quality (Caparra *et al.,* 2007) Carcass characteristics in details in different breeds have been studied by Prasad *et al.* (1981,1983), Karim and Rawat (1996), Karim and Verma 2001, Karim *et al.* (2002,2006) Sen *et al.* (2000, 2004), Singh *et al.* (2003), Aygun (2007).

Chemical composition of carcass

The water contents of the carcass are highest in the lambs at birth, it goes on decreasing with the age and the amount of fat goes on increasing. The ash contents of the carcass decrease because of the ceasing of growth of the lamb with age. The amount of crude protein on dry matter basis decreases with age. This is because of increase in body fat.

Nutritional value of meat

The chemical composition of meat varies considerably, depending on the particular cut, the breed of the animal and the degree to which the animal has been fattened and nourished. The fattening increases the fat content of mutton. The average composition of mutton is given in Table 12.8.

Table 12.8 Proximate composition and energy value of fresh muscle mutton.

Cut of meat	Protein %	Fat %	Water %	Ash %	Cal/100 g
Breast	12.8	37	48	-	380
Leg	18.0	18	64	0.9	240
Loin	18.6	16	65	-	220
Rib chop	14.9	32	52	0.8	360
Shoulder	15.6	25	58	0.8	300

Source: The Science of Meat and Meat Products. p 187 American Meat Institute Foundation, W.H. Freeman & Co., San Francisco, London.

Protein: Mutton is a good source of protein. It contains essential amino acids such as lysine and threonine. (Table 12.9). It can be used to supplement cereal proteins, which are deficient in lysine and threonine.

B Vitamins: It is a good source of folic acid, niacin, pantothenic acid and vitamin B-12 and fair source of riboflavin. Liver is a good source of niacin, folic acid, vitamin B-12 and vitamin - A.

Table 12.9 Essential amino-acid composition of beef, pork and mutton

Amino acids	Beef	Pork	Mutton
Isoleucine	5.1	4.9	4.8
Leucine	8.4	7.5	7.4
Lysine	8.4	7.8	7.6
Methionine	2.3	2.5	2.3
Phentlalanine	4.0	4.1	3.9
Threonine	4.0	5.1	4.9
Tryptophan	1.1	1.4	1.3
Valine	5.7	5.0	5.0

Source: The science of Meat and Meat Products. p 187, American Meat Institute Foundation. WH. Freeman & Co., San Francisco. and London.

Minerals: Muscles are rich source of phosphorus and potassium and fair source of iron, copper, cobalt, manganese and zinc. It is a poor source of calcium.

Carcass quality characteristics

The main characteristics influencing carcass value are as follows:

i) Carcass weight
ii) Carcass lean, fat and bone contents.
iii) Carcass confirmation and muscle thickness.
iv) The distribution of the weights of lean and bone between the different parts of the carcass.
v) Meat quality.

Characteristics of meat

The value of mutton depends upon its nutritive value, digestive value and consumer acceptance. The palatability of mutton depends upon colour, odour, flavour, juiciness, tenderness and texture. Measuring the physical and chemical qualities of meat and correlating them with eating qualities have attempted the evaluation of the eating qualities. At present the taste- panel method is relied upon.

Colour: The colour of the freshly cut mutton is due to reduced myoglobin, which is converted into oxymyoglobulin, which on further exposure is converted into metmayoglobulin leading to dark brown colour.

Aroma: Fresh raw mutton has a very slight aroma or odour. The mutton from younger animals has less odour than that from old ones of the same species. The feed fed also affects the aroma. The odours are

dependent on the conditions of storage. Putrid, sour or rancid odours are because of various chemical and microbiological changes taking place in mutton held under unfavorable conditions.

Flavour: It arises from muscle fibers on cooking. It is dependent on the age of the animal, the type of food and condition of storage after slaughtering.

Juiciness: Good quality mutton is juicier than poor quality meat, the difference being due to the high content of intra muscular fat. Tender mutton is juicier. Mutton becomes less juicy with the increasing cooking losses of meat fluid.

Tenderness and texture: These are the most important characteristics of the eating quality of mutton. The texture depends upon the size of muscle bundles and the amount of connective tissue present in the muscle portion. Coarse grained muscles have large bundles, whereas fine grained muscles have small bundles. The tenderness depends upon the water holding capacity.

Factors affecting growth of lambs

Body weights: Body growth affects the composition of the lamb. It has been observed by many research workers (Reid *et al.,* 1968) that the 63 percent, 95 percent and 88 percent of variation in ash, protein and fat, respectively are due to changes in body weight at slaughter.

Breed: The rate of growth varies from breed to breed, even if given same type of fodder and concentrate to all the breeds. The growth rate is affected by the adult body weight (Gackson, 1974).

Sex: The sex hormones of males and females affect their growth rate. The ewe differ from the ram in that it has slower growth rate, a more early maturing carcass and reaches a lower mature size due to the effect of oestrogen in restricting the growth of long bones of the body.

Castration: The castration of male decreases their growth rate and they mature at an early age. The appreciation of the central role of the sex hormones in growth and development as manifested in the consequences of castration have led to extensive study of the effects of the administration of natural or synthetic hormones to meat animals in order to influence performance (Hafs *et al.,* 1971).

These days there is an attempt to improve our promising indigenous mutton breeds like Mandya and Nellore through proper selection and cross breeding with superior mutton breeds like Suffolk, Dorset and South Down. This has become necessary to reach the dressing yield of

sheep, which is hardly 9.0 kg per animal to at least 12.0 kg per animal, a figure close to the world average. Parallel to it, there is a development of quality consciousness among the consumers in the country and to meet the demand and regulate marketing of live sheep, selection of a market lamb would playa vital role in future.

Transportation

Meat is produced in the slaughterhouses. However, the meat animals are produced in distant rural places and are required to be brought to the place of slaughter and sold to the butcher. Animals are generally purchased by the middlemen and transported on foot by trucks to the nearest slaughterhouse, where they are sold in lots. Meat produced is also required to be transported to the selling centers and cold storages as the case may be. Thus, the transportation of livestock, from their producing centers to the slaughterhouse and transportation of meat from slaughterhouse to the market places forms an important aspect of meat trade. Unless specific requisite care is taken during transportation, there is likely to be a great loss. Further this involves considerable economic losses due to mortality and shrinkage in live weight. While transporting the live animals care should be taken to eliminate all factors, which may contribute to deterioration of the condition of animal's health and bodily condition, which, ultimately influence the quality of meat. There is thus a need for providing market yard for sale of live animals in major sheep rearing areas. The market yard should have facilities for watering and holding animals for a few days. Meat when produced is very vulnerable and very much prone to get affected with extrinsic factors like temperature, contamination, dirt and microbes etc.

It is therefore, essential that utmost care be taken during transportation to safeguard meat from contamination. Meat carcasses must be transported on hooks in specially built vans with metal bodies and with ventilation arrangements. Whenever possible, transportation of meat by a refrigerated van is the ideal form of transport. Meat when being sold in butcher shop is in the naked form and a major quantity of meat is sold thus, when it is exposed to atmosphere, temperature, dust, infection, etc. As such this kind of marketing is not ideal. However, the trend of sale and purchase especially in urban city complexes are fast changing. Processed meat in small and large packs and in semi-prepared conditions in proper packaging is being marketed. This kind of marketing has many advantages. The consumer demand for smaller packs can be prepared in the processing unit itself, where high standards of hygienic conditions can easily be maintained, thereby completely

eliminating contamination during transportation. Besides, in smaller packages, as per the needs of consumer demand, much larger quantity can be transported from processing units to greater consumer areas, thereby economising on the transport, cost. At sale outlets, these smallIer packs be preserved in a proper chiller/cooler for days or weeks together. This is a great break through in marketing of meat as compared to old traditional system of sale at the butcher's shop. Sheep farmers' cooperatives can set up market yards and facilities for slaughter, in the major sheep rearing areas with a view to have organised meat marketing. Sheep and their products can also be marketed abroad more-profitably by these cooperatives. This will also generate employment opportunities to the needy persons. A few or all sheep breeders should join together to form an expert group and select an experienced person who knows the products and the foreign markets. Each sheep breeder should contribute a reasonable amount and make a central fund for meeting expenses of the expert group. A committee of sheep breeders may supervise the affairs. This committee according to the quality of the wool, carpet, skin and ram, etc, must fix price. A price list and illustrated catalogue should be published and the cost of the same be met from the central fund of the co-operative export group. Success of such a group will be excellent, if pursued persistently, honestly and without any rift or discontent among the participating members. Such co-operative societies can provide promising results in eliminating middlemen' s profit and provide more returns to the actual producers. This approach will be healthy and effective only when the participating members work with a sense of responsibility, honesty, fair-trading and sacrifice for the prosperity of industry leaving aside individual self-interest or greed when circumstances demand.

Export of sheep and goat meat and its potential

India's share to the world meat export is negligible being below 1.0%, whereas the major exporters and their share are USA (13.0%), Netherlands (12.4%), France (10.0%) and Australia (8.4%). The total meat export was expected to go up to the level of ₹ 7,000 millions during 1996-97 as compared to ₹ 6,150 million during 1995-96 showing around 14.0% increase (Table 12.10). At present sheep and goat meat export is about 2.0% of the total produced. Export of sheep and goat meat has shown 18.12% increase from 11 thousand tonnes in 1993-94 to 13 thousand tonnes during 1995-96 fetching foreign exchange of ₹ 630 million. By 2010 meat is expected to show a compound growth of 16.77% (₹ 7,200 million) and sheep and goat meat 17.78% (₹ 2,750 million). Country has the potential to enhance the export to 0.078

million tonnes mutton and lamb and 0.251 million tonnes of chevron to earn foreign exchange to the tune of ₹ 19,740 millions (Table 12.10).

Table 12.10. Export pattern of meat and meat products from India (₹ in millions).

Year	Monetary value	Growth rate (%) during the period
1980-81	614.9	—
1985-86	648.6	55.0
1990-91	1410.0	1174.0
1995-96	6150.0	3362.0
1996-97	7000.0*	138.2

Source: Annual Report (1996-97), Deptt. of Animal Husbandry and Dairying, Govt of India

Export of meat and meat products at higher unit value realization is expected to increase considerably in the near future in view of the establishment of export abattoirs and improvement of existing abattoirs and improved Rinderpest disease situation. Saudi Arabia, UAE, Oman, Bahrain are the major destinations for export of sheep and goat meat accounting for 90.0% of export. India being located in closer proximity of Gulf countries has the advantage in supplying meat at a competitive price. Meat produced is also lean in character and relatively free from harmful feed additive residues due to animals being reared in natural pasture grazing system. The sheep and goat meat exported has also preference in Gulf countries as it is guaranteed to be produced by Halal Method.

The immediate challenge is to boost the export as well as keep the domestic market price of goat and sheep stable. This could be possible by two ways: one by increase in meat production by increasing slaughter rate, improving slaughter and carcass weight, reduction in mortality,

Table 12.11. Sheep and goat meat production potential, domestic consumption and export surplus by 2000 A.D.

Parameters	Mutton	Chevon
Production potential (million tonnes)	0.248	0.801
Domestic consumption (million tonnes)	0.170	0.550
Export Surplus (million tonnes)	0.078	0.251
Export Value (million)	4,680	15,060

Export value of mutton and chevon assumed as US 2000 per metric tonnes.
Source: Koildaiali, 1996.

checks on the slaughter of immature animals, minimising tissue shrinkages due to poor transit facility. By these means from goat alone the meat production may be increased to 1.113 million tonnes (Rekib and Agnihotri, 1997). Another way is reducing species bias for meat consumption, thereby making available larger surplus for export. Goat meat has higher preference in the domestic market and increased goat meat production would spare lamb and mutton for export. It is an interesting development that co-operative ventures have taken up sheep and goat production in recent years.

Packaging

In India hardly 5.0% of raw meat is marketed in packed form, mainly in some organised meat factories. Fresh and processed meat has different packaging requirements for extended storage. It is essential to prevent external contamination, dehydration and chemical changes, retain colour, display the product in attractive and appealing manner and provide longer shelf life. In contrast to Western countries, where the society is generally well aware of the importance of packaging, goat and sheep meat caters in the country by tradition prefer fresh produce. A psychological barrier to frozen and packed meats considered not fresh exists. There is an urgent need to bring awareness among consumers, meat sellers and butchery community on the importance of meat processing.

Simple packaging systems such as LDPE, shrink package, might be quite useful for domestic market. Scanty work has been done in the area of application of vacuum packaging, modified atmosphere packaging, cryovac packaging and use of flexible pouches for packaging of thermo processed meat products for export purposes. In the absence of cold chain systems in the country, retort pouch holds a promising future rather than tin cans for marketing shelf stable ready to eat sheep and goat meat products.

Marketing structure

Live animal transaction and marketing of major sheep produce are mostly unorganized whereas marketing of wool is partly organized through a chain of intermediaries and commission agents extending from the sheep farmers to the wool processor. Under the prevailing conditions marketing of sheep produce involve many agencies, intermediaries and middle men hence it is difficult to assess their exact number and operational chain in the marketing structure. Further at the present, government, semi government or co-operative sector are not involved in the animal trade and the earlier involvement of few state

concern in such endeavor ended in fiasco due to mismanagement. The live animal trade in India has an inherent stigma i.e. it is mostly operated by lower cast of the society hence the organized business houses and the high cast traders usually avoid to involve in such business.

Local survey indicated that cost of sheep production excluding family labour was ₹ 23.14 and 11.6/kg of meat and wool respectively (Singh and Karim, 1997). Organized information on economics of sheep raring under farmer's management is meager for important sheep rearing regions of the country. However the socio-economic survey of sheep and goat farmers in semiarid region of Rajasthan indicated that rearing cost of sheep was ₹ 71 with gross annual return of ₹ 115 (Rawat and Riyazuddin, 1993). The proportion of sale receipt from the animal, wool, milk and manure was 57, 14, 16 and 13 % respectively. Studies conducted in south India indicated that the farmer harvested annual return of about ₹ 120/sheep/annum (Parthasarathy, 1990). Similar studies conducted in semiarid region of the country indicated that annual return for each rupee invested amounted to ₹ 1. 63, 2.17 and 1.71 for sheep, goat and cattle, respectively (Rawat and Riyazuddin, 1993).

Marketing of meat and meat products

Small ruminants' marketing involves buying animals from producers, assembling, transporting them to the wholesale market called "Bakra Mandi" and slaughtering. The sex and age wise composition of marketable surplus shows that the male kids form 48-56% of the total surplus while 30-40% of the adult females are etched. At primary producers level the culled aged, females fetch low price compared to males. However, the retail meat dealer sells meat of both animals at uniform price to get higher margin. Most of urban butchers slaughter one or two male animals for every 5-10 female animals. The current practice of live animal sale on per head/per pair/per group basis rather than on live weight basis and the absence of any established carcass grading system are helping the middlemen and butchers. Goat and sheep owners receive about 68% of the total realisation (Table 12.12) after slaughter and sale of meat and by-products account for costs and margins. The introduction of live animals and carcass grading or classification will motivate the farmers to produce good animals, which will benefit both producers as well as consumers. Setting of small viable slaughter house for cluster of villages and transporting packed meat to the urban centres will not only minimise involvement of middlemen but also minimise tissue shrinkage which other wise leads to an estimated loss of 21,000 tonnes of meat (200-250 g meat/animal) in goats alone (Rekib and Agnihotri, 1997).

Table 12.12. Price spread of sheep and goat showing margins of different agencies involved in marketing chain

Share of different agencies	% of share
Farmer	67.9
Trader	5.8
Wholesale meat dealer	8.0
Retailer	18.3
Total	100.0

Source: Naidu and Chadramouli (1995)

There is no well-integrated marketing system for meat and meat products in India. The sale of meat in super markets has not picked up significantly so far. No limits have been prescribed on pricing of live animals or its meat with wide variation in sale price. Presently there is no system of collecting and reporting market intelligence. There is need to establish sheep and goat meat development board. Special efforts are needed on the parts of state and central Government for collection and dissemination of market news, formation of goat and sheep breeders associations or co-operative societies, buildings, of cold chain systems, etc. for efficient meat marketing, and export to derive maximum benefits.

Economics of mutton production

Out of world population of 1,111 million (m) sheep, the country is host to 50.8 heads (Census, 1992) amounting to 4.6 % of world population. The country's 50.8 m sheep population with 30 % culling rate, contribute 15.2 m heads annually for slaughter, With average carcass yield of 10 kg, the sheep contribute 152 m kg mutton (average sale price of ₹ 100/kg) amounting to 15,240 m to gross national production (GNP), Kondaiah and Agnihotri (1995) reported that sheep contribute 170 m kg meat amounting to 5 % of total meat produced in the country. The mutton production was 120 m kg in 1981 which increased to 170 m kg by 1992 with annual increase of 2.2 %. Further the sheep population of the country with average wool yield of 750 g/ head/year produce 38.1 m kg wool which selling at average rate of ₹ 40/kg contribute ₹ 1,524 m to GNP, Surprisingly the return to the India farmer from sale receipt of manure is usually higher than wool, one of the major commodity for which the sheep are reared world over. The contribution of sheep on account of manure alone is ₹ 2,315 m to GNP. Additionally the sheep contribute ₹ 1,143 and 578 m to GNP on account of skin and milk respectively. It is evident that the sheep alone

contribute a total sum of ₹ 20,810 m/year to GN(Karim *et al.,* 2004). Riyazuddin *et al.* (1998) estimated that the contribution of sheep to GNP was ₹ 20,300 m while it was ₹ 13,780 m in report of Deoghare and Rekib (1996).

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13.
Milk

Milk is of commercial importance in some countries, but is used for home consumption in most of the countries. Some Indian communities and nomadic sheep farmers, during migration of flock, use sheep milk for kneading flour for making *chapaties*. Such *chapaties* do not dry up. Ghee is prepared from sheep milk in some countries. They are normally milked in the morning. Awassi is the most productive milk breed. It can yield up to 266 kg of milk in one lactation.

Milk producing breeds

Some of the Indian breeds of sheep can produce relatively large quantities of milk. A Lohi sheep can yield up to 3.6 kg milk in a day (Kaura, 1941), whereas, Kuka sheep can produce 1.8 to 3.6 kg of milk per day (Kaura, 1942). Sonadi breed can produce 1.0 to 1.5 kg milk daily (Anon, 1953). Malpura, Rambouillet × Malpura, Chokla, and Rambouillet × Chokla can produce 45.0,54.0,41.4 and 45.9 kg milk, respectively in a lactation of 90 days (Table 13.1). Maximum milk yield per day has been observed to be 1.0 kg (Sahani *et al.,* 1975). Mean lactation yield for Bharat Merino has been reported to be 45.3±1.7 kg (Table 13.1).

Milk production can be affected by the weight of sheep (Castellanos and Valancia, 1982, Acharya and Bawa, 1971), nutrition and season (Sahni *et al.*, 1975; Acharya and Bawa, 1971), birth weight of lamb (Acharya and Bawa, 1971) and breed, age and sex of lamb (Wallace, 1948; Acharya and Bawa 1971). Maximum milk yield has been observed in fourth lactation. Sheep milk contains 6 to 8 per cent fat. Milk production does not affect wool yield.

Lactation can affect the length of the rebreeding interval; suckling by lamb hastens the involution of uterus. It has been observed that ewes that lamb early but which lose their lambs, are more likely to become pregnant again during the same breeding season, although Hunter (1968) has pointed out that this is an unsatisfactory basis for comparison.

Anatomy of udder

The right and left halves of the udder are separated by inter mammary groove. There is no communication between the two halves.

Table 13.1. Milk yields in sheep

Country	Breed	Yield/ day (kg)	Period measured	Source
Brazil	Santa Ines	0.18	92	Bellaver *et al.,* 1980a
Brazil	Morada Nova	0.21	92	Bellaver *et al.,* 1980a
Cyprus	Chios	1.27	209	Louca, 1972
Cyprus	Chios	1.28	90	Mavrogenis, 1982
Egypt	Barki	0.71	84	*Aboul-Naga et al.,* 1981
Egypt	Merino	0.85	126	El-Sherbiny *et al.,* 1981a
Egypt	Ossimi	0.75	126	El-Sherbiny *et al.,* 1981a
Egypt	Ossimi	0.78	84	*Aboul-Naga et al.,* 1981
Egypt	Rahmani	0.77	84	*Aboul-Naga et al.,* 1981
India	Avikaline	0.47	92	Kishore *et al.,* 1983
India	Avivastra	0.45	92	Kishore *et al.,* 1983
India	Chokla	0.46	90	Sahni and Tiwari, 1975b
India	Jaisalmeri	0.40	90	Sahni and Tiwari, 1975b
India	Malpura	0.50	90	Sahni and Tiwari, 1975b
India	Merino	0.70	112	Mallikeswaran *et al.,* 1980
India	Nilgiri	0.65	112	Mallikeswaran *et al.,* 1980
India	Bharat Merino	0.50	90	Mehta *et al.,* 2000
India	Merino x Nilgiri	0.67	112	Mallikeswaran *et al.,* 1980
India	Rambouillet x Chokla	0.51	90	Sahni and Tiwari, 1975b
India	Rambouillet x Malpura	0.60	90	Sahni and Tiwari, 1975b
Iran	Awassi	1.16	207	Kaschanian, 1973
Italy	Sardinian	0.86	44	Dattilo and Congiu, 1979
Israel	Assaf	1.34	156	Eyal *et al.,* 1978
Kenya	Corriedale	1.36	70	Bush, 1965
Lebanon	Awassi	0.68	150	Bhattacharya and Harb, 1973
Morocco	Middle Atler	1.90	28	Kabbali, 1977
Mexico	Pelibue	0.53	84	Castellanos Ruelas and Valencia, Z.M., 1982
Nigeria	West African Dwarf	0.42	70	Adu and Ngere, 1979
Philippines	Shropshire	0.06	73	Villegas and Cruz, 1960
Saudi Arabia	Najdi	1.35	84	Ramadan *et al.,* 1977
Trinidad	Blackhead Persian	0.63	84	Butterworth *et al.,* 1968
Tunisia	Tunisian Barbary	1.06	35	Sarson, 1972
Venezuela	West African	0.60.	56	Combellas, 1980

This prevents the spread of infection from one part to the other. Each half is composed of secretary and some supporting connective tissue. The secretary tissue consists of numerous alveoli or tiny chambers lined with many secretary cells. Each alveolus is supplied with tiny capillaries, which lie outside the secretary cells. Small muscle fibers surround each

alveolus, which cause contraction of alveoli and produces "let down" of milk (Fig 13.1). Each alveolus is drained by terminal duct. The clusters of alveoli and terminal duct from a lobe. Terminal ducts form interalobular ducts, which in turn join to form interlobular ducts. These further join to form galactophores, which empty into the milk cistern. This is continuous, immediately below with the teat cistern. The teat cistern is joined with streak canal, a narrow tube that opens at the lower end of the teat. The streak canal is surrounded by a sphincter, which remains constricted and prevents leakage of milk until milking commences. Milk yields of different breeds of sheep are presented in Table 13.1.

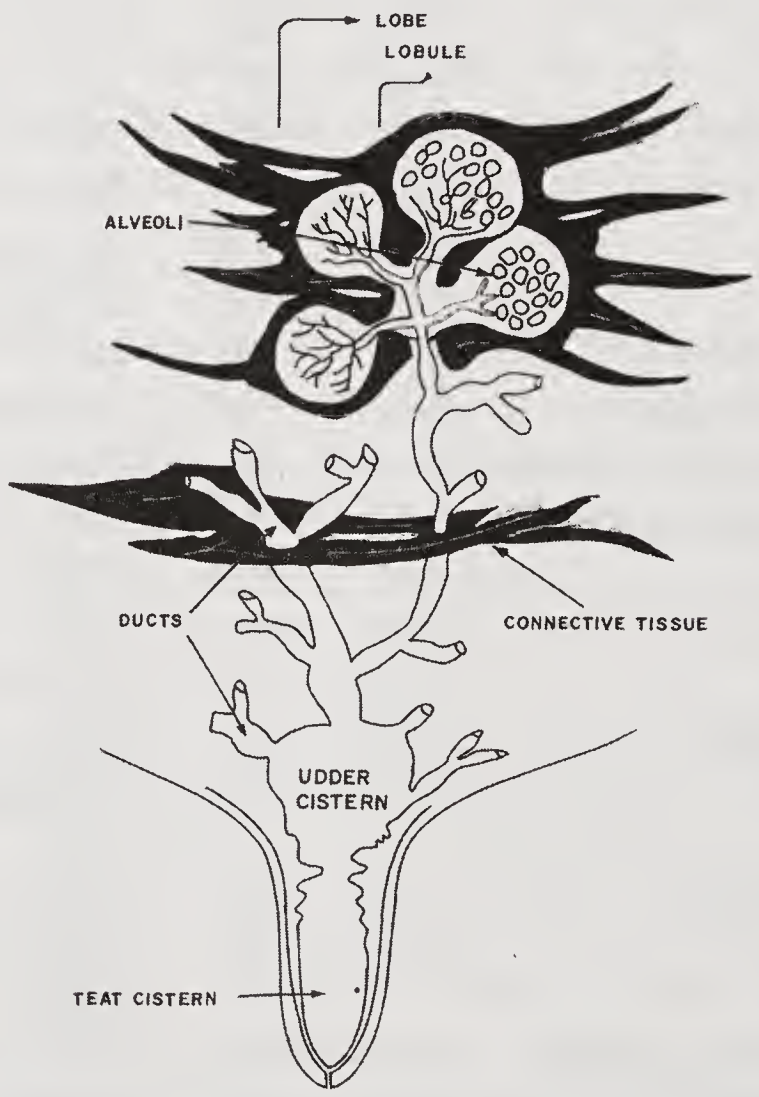

Fig. 13.1 Relation of ducts with lobule and alveola

Milk secretion

Hormones play part in the development of mammary tissue, initiation and maintenance of milk secretion and ejection of milk into the cistern and teats. The ovarian steroids are involved in the development of mammary tissue and rate and extent of ducts and alveoli development. The hormonal mechanisms that control the initiation of milk secretion at lambing are complex and not completely understood (Demiruren *et al.,* 1971) but the changes in the ovarian steroids are

Table 13.2. Composition (%) of plasma and milk

Attributes	Blood plasma	Milk
Water	91.00	87.00
Glucose	0.05	4.80 (Lactose)
Serum albumen	3.20	0.52 (Lactalbumin)
Serum globulin	4.40	0.05 (Globulin)
Amino Acids	0.03	2.90 (Casein)
Lipids	0.09	3.80
Phospholipids	0.20	0.04
Cholesterole	0.17	Traces
Calcium	0.09	0.12
Phosphorus	0.11	0.10
Sodium	0.34	0.15
Potassium	0.03	0.15
Chlorine	0.35	0.11
Citric acid	Traces	0.20

involved, particularly the increase in oestrogen in relation to progesterone, the considerable release of oxytocin at lambing and the increase in the secretion of adrenal steroids.

It starts after the birth of a lamb. The blood, which nourishes the foetus in the uterus, starts flowing in milk vein after birth, which enlarges and starts supplying the udder. Before the birth the ovarian hormones suppress the lactogenic hormones, but after birth, the secretions of ovarian hormones are suppressed. Excess production of lactogenic hormones results in the secretion of milk.

In addition to hormones, the size of ducts also regulates the blood flow, which in turn affects the milk secretion. All essential components of milk are brought to udder by blood, which in turn are converted into milk. It is clear from Table 13.2 that as compared to blood, milk contains 90 times more sugar, 9 times lipids, 5 times potassium, 13 times calcium and 10 times phosphorus.

Milk production is mainly confined to the Near East countries such turkey and Iran and to Southern and Central Europe (Greece, Hungary, France, Italy, Spain and the Czech and Slovak Republic (Table 13.3). Asia and Europe together produce 79% of total milk production from

Table 13.3. World sheep milk production

	Milk (x1000 tonnes)	Contribution (%)	Milk (kg(per inhabitant
Asia	3586	44.4	0.9
Africa	1641	20.3	1.9
Europe	2812	34.8	3.9
Greece	650	0.8	72.2

sheep, while on per capita basis milk production in Europe exceeds that of any other continents. Greece has the highest annual sheep milk production per capita in the world (Zygoyiannis 2006).

Chemical composition of colostrums

The onset of lactation occurs with parturition. Initially, the secretion is of colostrum, which is high in fat, protein and immunoglobulins and low in lactose (Table 13.4). During first 2-3 days the composition of the secretion changes from colostrum to that of normal milk.

Table 13.4. Composition of colostrum (g/ dl)

Components	Species		
	Cow	Goat	Sheep
Water	73.3	81.2	58.8
Protein	17.6	5.7	20.1
Fat	5.1	8.2	17.7
Carbohydrate	2.2	5.7	2.2
Ash	1.0	0.9	1.0

Chemical composition of milk

The aspects of the natute and composition of the animal's diet that has influence on the fat content of its milk and its conposition has been reviewed by Sanz Sampelayo *et al.* (2007). The concentration of all constituents is much greater than in cow's milk resulting in the energy content being approximately 65 per cent greater. The ewe suckling two lambs generally produces 40 per cent more milk than an ewe at the same level of nutrition but suckling a single lamb (Table 13.5). The number

Table 13.5. Average composition of milk of domestic animals

Species	Percentage composition				
	Total solids	Fat	Protein	Lactose	Ash.
Sheep *(Ovis aries)*	19.3	7.4	5.5	4.8	1.0
Cattle *(Bos taurus)*	12.7	3.7	3.4	4.8	0.7
Cattle (B. *indicus)*	13.5	4.7	3.2	4.9	0.7
Buffalo *(Bubalus bulalis)*	17.2	7.4	3.8	4.8	0.8
Goat *(Capra hirca)*	13.2	4.5	2.9	4.1	0.8
Horse *(Equus cabdlus)*	11.2	1.9	2.5	6.2	0.5
Donkey *(E. asinus)*	11.7	1.4	2.0	7.4	0.5
Bacterian camel *(Camelus bactrianus)*	15.0	5.4	3.9	5.1	0.7
Dromedary (C. *dromedarius)*	13.6	4.5	3.6	5.0	0.7

Source: Jenness, 1974

of lambs suckled has a greater effect on milk yield than a wide range of nutrition in both pregnancy (Wallace, 1948) and in lactation (Gardner and Hogue, 1964).

The composition of milk depends upon the production level of the ewe and the number of lactations. The composition of milk changes with the advancement of lactations. The concentration of fat, protein, solid not fat and ash is highest in colostrum. The concentrations of these decrease with the advancement of lactation and then again increase at the end of the lactation. The concentration of lactose first increases and then decreases (Ashton *et al.,* 1964). The concentration of calcium increases in the beginning of lactation and then becomes stable. The concentration of magnesium remains stable throughout. The concentration of sodium is directly related with lactation length and inversely with potassium (Ashton and Yousef, 1961) (Table 13.6).

Table 13.6. Chemical composition of milk obtained from cow, buffalo, sheep and goat

Component	Unit/dl	Sheep	Goat	Cow	Buffalo
Water	g	78.9	85.6	87.3	87.0
Solid not fat	g	10.3	9.0	8.5	9.5
Total solids	g	-	17.0	13.2	10.5
Ash contents	g	1.1	0.9	0.8	0.8
Lipids	g	8.9	4.9	4.5	7.0
Carbohydrates	g	5.0	4.7	4.6	5.0
Proteins	g	6.2	4.1	3.5	3.8
Lactose	g	4.6	4.7	4.8	4.4
Calcium	mg	139.0	130.0	125.0	-
Chloride	mg	54.0	159.0	103.0	-
Phosphorus	mg	-	16.0	12.0	-
Potassium	mg	190	181.0	138.0	-
Sodium	mg	-	41	58	-
Magnesium	mg	-	16	12	-
Sulphur	mg	31	16	30	-

The physico-chemical characteristics of sheep milk have been reviewed by Park *et al.* (2007). Sheep milk contains higher levels of solids and major nutrients than goat and cow milk. Lipids in sheep milk have higher physicalcharacteristics than in cow milk, but physico-chemical indices vary between different reports. Renneting perameters in cheese making of sheep milk are affected by physico-chemical properties, including pH, large casein micelle,more calcium per ccsein weight,and other mineral contents in milk, which cause differences in coagulation time. The average fat globule size is smallest in sheep milk

followed by goats and cow milk. Sheep milk proteins can provide non immune disease defence and control microbial infections.

Milk consists of water, lipids, proteins, sugar, minerals, vitamins, enzymes and some cellular material. There is a great deal of variation in milk composition among breeds and individuals. Milk produced by cow, buffalo, sheep and goat appears to be similar, but they differ in chemical composition (Tables 13.4, 13.5 and 13.6) .

Carbohydrates: Lactose is the main carbohydrate and is synthesised in alveoli, it does not occur anywhere in mammalian tissues.

Protein: The chief types of proteins found in milk are casein, lactalbumin and lactoglobulin. Casein and lactoglobulin comprise about 90 per cent of the protein of milk. These two and lactalbumin are sythesised in gland from amino acids.

Fat: The lipids of milk consist of true fat, phospholipids, holesterols, pigments and fat soluble vitamins. The true fat forms the large part of milk lipids, other components comprise only about lone per cent of total lipids.

Minerals and Vitamins: Calcium and phosphorus found in milk are directly derived from blood. The same is also true for vitamins. The concentration of milk proteins, fat, carbohydrates, ash and solids not fats are higher than that found in cow, buffalo and goat milk. The water contents of ewe milk are the lowest. The composition depends upon fodder, climate, atmospheric temperature, etc.

Milk production

The amount of milk produced by an ewe affects the growth rate of lambs. The milk yield of the ewe can be estimated by two methods. The difference in body weight of lambs before and after milk feeding gives the amount of milk suckled. This is done several times in a day. We can calculate the milk yield from this (Owen, 1957). In second method sheep is given an injection of oxytocin and then she is milked 2 to 4 times in a day. The total amount of milk thus collected gives the yield of ewe for the day (Coombe *et al.,* 1960)

Milk production performance: The lactations of Marwari goats started in the months of September and October and was almost completed till April. The effects of winter were pronounced on the lactation period of the goats in comparison to summer months. The 90-days lactation yield, total lactation yield, lactation length and milk fat % and SNF % are presented Table 13.6. The lower milk yield with low fat % were observed in goats housed without shelter while the higher lactation milk yield with higher fat % was found in the goats housed in PHS.

However, the performance of goats, kept in thatched housing system, was found to be intermediate in terms of milk production performance. The reasons for higher milk in Pacca Housing System were due to complete protection of goats from chilly winds in night hours of winter seasons. Whereas, the animals in open Housing System and Thatched Housing System could not be protected for cold winds.

Factors affecting milk production

The use of sheep for milk production is not very popular in India. Thus the studies of the factors affecting milk production in ewes are rare. However, regardless whether the sheep are used for milk production or not the morphological traits have an important influence on lamb rearing (Sagi and Morag, 1974; Kirk *et al.,* 1980). The good udder formation, particularly position and size of teats ensures proper lamb rearing. Abnormalities of udder and teat morphology make milking difficult. This may be responsible for higher mortality in lambs and inflammation of udder. Gonzalo *et al.* (1985) observed existence of close relationship between morphological traits of udder and susceptibility to mastitis. Milk yield of ewe is affected by the morphology of the udder (Gootwine *et al.,* 1980; Labussiere *et al.,* 1981; Mavrogenis *et al.,* 1985; Woolny and Nizrdkowaski, 1985). Correlations between length, width and depth of udder and milk yield have high positive correlations (Milkus, 1968). Some of the factors have been discussed below.

Breed: The milk yield of the ewe differs from breed to breed (Salevno and Malossini, 1968; Ricordean and Flament, 1969). Lohi, Malpura and Sonadi are good milkers, whereas Chokla is a poor milker.

Age: An ewe in good health improves in her milk yield upto her fourth lactation. The milk of a young ewe is richer in fats and solids than that of aged ewes. The amount of fat and protein increases with the increase in lactation length. (Ricordean and Flament, 1969).

Length: The peak milk yield is reached in first 2 or 3 weeks. It starts declining after that.

Period of year: In spring and early rainy season when the grass is young, ewes produce more milk than they do in dry, hot weather.

Estrous: In majority of the cases, estrous reduces the milk yield.

Water supply: Milk is reduced if the ewes are given restricted supply water.

Weight of ewe : Milk production to large extent depends upon the size of the ewe.

Method of suckling: Milk production increases by 40 per cent if an ewe suckles twins (Peart *et al.,* 1972). Merino ewes suckling crossbred lambs produce more milk than when suckling purebred lambs (Moore, 1966).

Nutrition: Milk production is directly related with nutrition. Concentration of calcium and phosphorus increase if the ewes are given concentrate mixture (Ashton *et al.,* 1964).

Fear and excitation: They have ill effect on milk production. They cause the release of adrenaline, which in turn reduces the milk production.

Health: The milk from healthy ewes is nutritious. The milk yield decreases in mastitis. It also results in increase in chloride concentration and decrease in lactose. Amount of fat also decreases in disease.

Number of lactations: The amount of solid not fat and fat, increases with the number of lactations.

Dry period: If dry period is longer, ewe will produce more milk.

Hereditary: It affects the milk production.

Hormonal imbalance: Udder development and milk synthesis are affected by the release of estrogen, oxytocin, and prolactin hormones. Oxytocin helps in the release of milk.

Ambient temperature and humidity: Shinde *et al.* (1990) observed that milk yield per day decreased with simultaneous increase in ambient temperature humidity.

In addition to these, milk production is also affected by change of place, weather, constitution of udder, time of milking etc.

Sheep milk products

The use of sheep milk for manufacture of different milk and milk products is increasing, although the proportion is much less compared to cow and buffalo milk worldwide, but it is much better organized in some countries than in others. The manufacturing of sheep milk commercially on the farm for direct sales is done for pasturised beverage, evaporated milk, ice cream, milk powder etc. These products due to their nutritional and antiallergenic properties, can be a beneficial alternative milk product for children, young and sick (Pandya and Ghodke, 2007)

Sheep milk as medicine

Sheep milk is used as medicine in case of minor fractures and sprains. Whenever there is fracture sheep's milk is gently rubbed over the site. It reduces swelling and pain.

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14.

Health Management

Productivity and the financial success of sheep management depend on balancing the cost of production with the return from sales. In this crude equation, the contribution by the ewe, which is most likely to vary between seasons, is the value of lambs available for sale. Diseases cause great losses in case of sheep. Diseases affect through mortality and morbidity. Change of climate decreases the adaptability of sheep to diseases. Incidences of diseases increase if the sheep are fed succulent grasses in place of dry grasses, given stagnant dirty water to drink and allowed to sit on moist floor at night. Grazing sheep in large numbers in limited area not only depletes the grasses but also increases the incidences of diseases due to parasites. They can also develop cough, pneumonia and diarrhoea as a result of this.

Unlike other animals, it becomes difficult to observe symptoms in sheep. They continue to move with the flock even if their health is very bad. A sheep lags behind in the flock only if it is sick. Sheep farmer should observe carefully the behaviour of his sheep from the time they move out for grazing till they return from grazing. He should have a round of the flock in the morning before they move out for grazing. Cough, sneezing and unthriftyness are the signs of sickness.

Disinfection

The disinfection of a building implies the elimination from a house of all microorganisms that are capable of causing disease. A disinfectant is the agent that is capable of achieving this and in livestock farming it is usually a chemical agent. The process of disinfection of a building can take place by the use of natural disinfectants and by artificial disinfectants.

Sunshine, heat and some chemical agents kill bacteria. Sunshine is the most powerful disinfectant. Its efficiency is entirely due to the ultra violet range of wavelength and its most effective range is between 2800 and 2400 A°. Desiccation by wind and fresh air also contributes to the disinfection. The temperature of air and high temperatures accelerate the destruction of exposed microorganism. Sheep sheds can be disinfected by using steam, boiling water and by synging. Some

Table 14.1. Common disinfectants and their usages

Name of disinfectant	Utility	Concentration	Mode of application	Remarks
Bleaching powder	It is a powerful disinfectant, rapidly inactivated by organic matter, can be used for disinfection of sheep sheds when a contagious disease has occurred.	It should not contain less than 30 per cent chlorine.	Dusting	Protect it from air, light and moisture.
Boric acid	Weak antiseptic 2% aqueous solution can be used for washing infected eyes.	2% aqueous solution	Splashing	Good for minor infections
Caustic soda	It has powerful germicidal action. Destroys virus of sheep pox and Foot and Mouth Disease. It can also be used for the disinfection of sheep sheds.	2% aqueous solution for disinfection of shed and 5% for killing anthrax and B.Q. spores.		Spray While spraying protect eyes, hands and skin, use gloves.
Cresol	Its solution is prepared by dissolving in soap solution. It is effective against Tuberculosis and Johne's disease bacteria but not against viruses and spores, can be used for the disinfection of shed.	2-3 per cent solution	Spraying	Prepare in soft water as soap precipitates in hard water.

important disinfectants are given in Table 14.1. One disinfectant does not kill all the bacteria. Humidity reduces the killing power of these disinfectants; therefore, cleaning is very essential.

Using chemical disinfectants generally carries out the disinfection of farm buildings. Chemical disinfectants act by coagulating or denaturation of the protein of the bacteria. They are phenols, alcohols, acids and salts of heavy metals. Metallic salts prevent the development of the cell because they are protein precipitants. Mercury and silver salts are the most potent. Phenols also act as protein denaturants.

Before disinfection operation is taken up, dung sticking to walls should be removed. They should be scrubbed thoroughly. If the floor of the shed is not made up of cement concrete, 8-10 cm soil should be removed and fresh soil mixed with slacked lime should be put. The cement flooring can be disinfected with 4 per cent sodium carbonate solution. The shed should not be used for tying animals within 24 hours of disinfection. It becomes difficult to diagnose diseases in sheep. Recording of physiological norms (Table 14.2) helps in diagnosis:

Body temperature: Veterinary clinical thermometer is used for recording rectal temperature. It is inserted deep into rectum and kept there for one minute. The temperature recorded in the morning is considered to be normal. The temperature recorded in the after noon is little higher and it returns to normal in the evening.

Pulse rate: The pulse is examined by catching the tail at the base between two fingers. The number of pulse per minute gives the pulse rate.

Respiration rate: Inhalation and exhalation of air in the lungs is known as respiration. These can be counted by keeping a hand in front of nostrils or by counting the expansions and contractions of chest per

Table 14.2. Rectal temperature, pulse and respiration rate of sheep during different seasons (Kaushish *et al.*, 1976)

Attributes	Time	Summer season	Rainy season	Autumn season	Spring season
Rectal Temp. (°C)	Morning	37.8 ± 0.05	37.2±0.02	37.5± 0.08	37.6±0.27
	Evening	38.5± 0.06	38.0 ±0.03	38.8± 0.05	38.8±0.06
Pulse Rate (PM)	Morning	82.6±2.14	82.1 ±1.90	69.4±1.77	82.6 ±2.41
	Evening	99.3 ±2.88	120.5±3.36	94.8±2.16	94.6±2.40
Respiration Rate (PM)	Morning	31.7 ±2.02	56.9± 4.39	39.2±2.50	26.1±1.10
	Evening	56.3 ±2.97	127.2±5.35	41.5±1.80	43.9±2.30

minute. The normal values for rectal temperature, pulse and respiration rates are given in Table 14.2. (Kaushish *et al.,* 1976).

Depending upon the aetiology, sheep diseases can be divided into following groups:

A. Bacterial
B. Viral
C. Protozoan
D. Parasitic and
E. Miscellaneous

Bacterial diseases

Bacteria are present everywhere in the world. They are present in fresh and saline water, inside and outside the body and in hot and cold water. They differ in shape and size. They may be round or rod like. Some of the bacterial diseases found in sheep are described below.

Haemorrhagic septicemia

It is a contagious disease, which occurs, in rainy season. Bacteria named Haemorrhagic septicaemia cause it. This disease develops in animals, which are not vaccinated.

Symptoms: The body temperature rises to 40-42°C. Animal feels pain in throat region and has difficulty in respiration. It becomes lazy. The tongue protrudes and there is salivation. If the animal lives for a day or two, it develops pain in belly.

Treatment: Animal can be saved if given intravenous injection of 33 percent sulphamezathine at the outset of the disease.

Prevention: The disease can be prevented if sheep are given vaccination against this disease.

Black quarter (Black leg)

This is also known by the names of Fud, Suja, Chirchira, Budta, Takli, Ghatia Tav, etc. Mostly sheep in good health are affected. It is caused by *Clostridium chauvei.* (Minnett, 1948). This bacterium lives in soil and develops in the intestine. The bacteria enters through scratches in skin or injuries. This disease occurs in rainy season.

Symptoms: Temperature rises to 39.5-41.5 °C. The sheep becomes lame and stops eating and rumination. The skin becomes purplish black, swollen, edematous and leathery over the lesion. Crepitation, which is common in cattle usually not much seen in sheep. The swelling is hot and painful. The disease may cause sudden death or the animal may

show stiffness and staggering gait. The pulse rate varies between 90 and 100 per minute.

Treatment: Antiserum prepared is helpful. Injections of Terramycin are also helpful.

Prevention: Sheep should be vaccinated in the beginning of rainy season. Dead animals should be buried and skin should not be removed. Lime should be put on dead body. Isolate the suspected animals. Disinfect the utensils used for affected animals. Burn the fodder used by dead animals.

Enterotoxaemia

The disease develops in adult, as well as, in young lambs. It is caused by *Clostridium welchi* Type D (Gardner, 1973). This disease develops due to supplementation or sudden change in diet. This disease develops when the sheep are grazed in gram harvested fields or at the start of rainy season. This disease develops in lambs after heavy milk feeding.

Symptoms: Sheep circles in one direction. It starts smelling earth and pretends as if it is grazing. Rise in body temperature is also observed occasionally. There may be sudden death or the sheep may jump into the air, fall and go into convolutions. If these live longer, head may be thrown back on one side. The temperature may rise by 2-3 °C. Presence of sugar in urine (2-6 per cent) is an important feature. Sheep may show nervous symptoms. Mortality rate is 90 to 100 per cent.

Treatment: It was thought that there is no treatment for this dreaded disease. The author and one of his colleagues while working at Central Sheep and Wool Research Institute, Avikanagar (Rajasthan), have developed a treatment for this disease. They could save 91.6 per cent of the sheep in which the symptoms of this disease developed by drenching 50 mg of potassium permanganate in 100 ml of water. Such sheep started grazing after 2-3 days. (Dube and Kaushish, 1981; Kaushish *et al.,* 1995).

Prevention: To prevent this disease, sheep should be vaccinated. Careful feeding programme of younger stock helps in control of infection.

Foot rot

This disease develops during rainy season and continues till winter. If diseased animal is not treated in time, the animal becomes lame, weak and may die. The disease is caused by *Sporophorus necrophorus.* It causes foot rot. This disease occurs in one or more hooves. The incidences of disease are less in summer.

Symptoms: Affected sheep becomes lame and lags behind. Bad smell is emitted from the effected feet. At the junction of hoof with skin it becomes soft. The hooves may fall off. Sheep becomes unable to graze, grows weak and may die in 12-15 days.

Prevention and cure: Sheep should not be allowed to graze in pastures, where the ground is wet. Sheep shed should have aluminum or cement concrete footbath, which should have 20 per cent copper sulphate or 6 per cent formaldehide solution. This should be done twice a day. All sheep when they return from grazing should be passed through it. Affected sheep should be retained in the shed, till they become all right. They should be vaccinated (Egerton and Roberts, 1969).

Lamb dysentery

This is a dangerous disease of lambs. It is of bacterial origin. *Clostridium perfringens* Type B causes severe dysentery in young lambs. In affected group of lambs morbidity may reach as high as 20 to 30 per cent. It is prevalent in cold weather and in over crowded forms.

Symptoms: The syndrome of lamb dysentery usually occurs in lambs less than two weeks old and is manifested by sudden death without premonitory signs in per acute cases. In more common acute form, there is severe abdominal pain, recumbence and failure to suckle milk, the passing of brown fluid faeces some times containing blood. Death usually occurs after a period of coma and within 24 hr of the onset of illness.

Treatment: Contact veterinary doctor for treatment. Wool around anus should be cut to prevent flies from laying eggs.

Prevention: If there is disease at the time of birth of the lamb, change the enclosure 2-3 times. Vaccination, preferably with type specific toxoid or bacterin, is the only preventive measure available.

Lamb arthritis

The incidences of this disease are more in the lambs born in dirty sheds. It could be suppurative or nonsuppurative in nature.

Non suppurative: It is caused by bacteria. The lamb becomes lame from one or two feet. Lamb feels pain in joints when pressed. Stops suckling. Pus is formed in the swollen joint. Lamb may automatically become all right.

Suppurative: Caused by *Streptococci, Corinea* or *Coli* bacterium. Joints become swollen and painful. Mobility of joints decreases. Temperature

rises to 40.0 to 41.0°C. Bad smelling pus comes out of swollen joints. Disease spreads from this pus.

Treatment: Get treatment from veterinary doctor. Economic aspect should also be kept in mind while treating the affected lamb. Naval cord must be painted with tincture iodine at birth. Keep lambs in clean sheds.

Inflammation of naval cord

It is a common disease of lambs. It may also result in death of lamb due to tetanus. Attack of *Streptococci* or *Corinea bacterium* occurs due to the soiling of naval cord and there may be pus formation. Sometimes maggot formation results (Newson and Thorpe, 1938).

Symptoms: Lamb becomes restless and feels pain. There may be fever and deaths also.

Prevention and treatment: Naval cord should be cut at a distance of 5-7 cm and tincture iodine applied. Medicine should be applied till it becomes dry and falls down.

Tetanus

Tetanus is a highly fatal and infectious disease of sheep caused by toxins of *Clostriduim tetani,* which is found in soil in large numbers. (Haberman and Wellhorner, 1972). It can affect animals of all the ages. High incidence of tetanus may occur in young lambs following tail docking or adults after shearing. Docking by the use of elastic band ligatures appears to be especially hazardous (Mahoney, 1949). Bacteria enter the body through wounds and produce toxins under anaerobic conditions.

Symptoms: Cases appear 3-10 days after docking and shearing in sheep and lamb. There is rise in temperature and a general increase in muscle stiffness is observed. There is trismus with restriction of jaw movements, prolapse of third eye lid, stiffness of hind legs, causing straddling gait and animal becomes sensitive to light and sound. The animal dies within a few hours of the development of symptoms. The temperature and pulse are within normal range in early stages but may rise later when muscular tone and activity are further increased.

Prevention: The treatment of this disease is very costly. The response to treatment is poor. Lambs should be put on clean place immediately after birth. Change shed if the spores of these bacteria are present there. Give tetanus toxoid injection within 15 days of birth. Tetanus antitoxin is usually administered is effective but is of little value once symptoms appeared.

Pneumonia

The disease occurs due to hot, cold, dust particles, bacteria, viruses and fungi in young and adult sheep. Lambs may suffer, if not protected, from cold. Mishra *et al.* (1970) did bacteriological examination of morbid materials from cases of sheep pneumonia. Verminous pneumonia has been reported from Bengal by Mohan, (1948).

Symptoms: There is copious discharge from nose, which becomes thick with the passage of time. Cough and rapid respiration also occur. Lambs stop suckling, become weak and may die.

Treatment: Animals should be kept in comfortable place. They should be given antibiotics and antipyretics.

Tuberculosis

It is caused by *Tuberculus bascili.* The disease can, be contacted through drinking raw milk. It can spread from sheep to human begins (Kaushish, 1992b).

Symptoms: This causes tonsils. This may affect intestine and lungs.

Prevention and treatment: Sheep should be examined for the disease and given specific treatment. Affected animals should be separated from healthy animals.

Vibriosis

Abortion is caused by *Campylobacter foetus, which* was formerly called *Vibrio foetus,* during last 6 weeks of pregnancy. Diagnosis is from the history and isolation of causative agent from foetal stomach, visceral organs and brain.

Symptoms: The disease is suspected in flocks in which there is an increase in the number of services per conception. Abortion may be the only symptom, but in most cases, there may be brown mucopurulent discharge for a few days. The foetus born is oedematous.

Prevention: General hygienic measures and disposal of foetal discharge and membranes will help a long way in checking the infection. An ovine vaccine is effective in preventing abortion when used prior to breeding or in early gestation (Bryner, 1976).

Brucellosis

This disease is neither as prevalent in sheep nor as severe as vibriosis. Once a sheep is affected, the infection continues through out the life of sheep. The disease affects the rams. *Brucella ovis* causes epidedymitis in

males and may cause abortions in ewes. It is caused by *Brucella meletences*, *B. abortus* or *B. ovis* (Meyer, 1974). The bacteria of this disease enter body through injuries, eyes or through skin.

Symptoms: The latent period of this disease varies from 15-20 days. At first, there is rise in temperature, which falls and again rises. There is lot of sweating, pain in knee joints, anorexia followed by weakness. There occurs mucopurulent discharge from vagina within few days of service. The abortion occurs near term.

Prevention: Wear hand gloves while handling aborted foetus or placenta of such sheep. Aborted foetus should be burned. Get rid of the infected rams. Vaccination of rams gives good results. General hygienic measures be practiced.

Leptospirosis

This disease is caused by *Leptospira pomona,* or *L. grippotyphosa.* These bacteria develop in blood after entering through skin, mouth, genital organs, eyes or through respiratory tract. They leave the body through urine. There may be acute haemolytic anemia with haemoglobin in urine.

Symptoms: There is sudden rise in body temperature, followed by anorexia and abortion. Sheep may also die in 3 to 4 days.

Prevention: Aborted foetus should be burned or buried. The vaccination of this disease is not yet available (Weisman, 1967).

Anthrax

This disease is cased by *Bacilus anthracis.* This is a very serious disease.

Symptoms: It is a percute disease characterized by septicemia and sudden death (Kaushish, 1992b). In acute cases, sheep may die in a short period, but fever, muscle tremor; dyspnoea and congestion of mucosa may be observed. Blood may come out of natural openings such as nostrils, mouth, anus and urethral orifice, which does not coagulate. On postmortem examination, blood spots are observed. There may be enlargement of spleen.

Prevention: General hygienic measures should be taken. The dead body should be buried after putting lime on it. Sheep should be vaccinated (Lincoln *et al.,* 1964).

Viral Diseases

Some of the important viral diseases of sheep are described below:

Blue tongue

Blue tongue was first reported in India in sheep and goat in Maharashtra in 1961 and subsequently report on the occurrence of this disease from other parts of the country has also been made. In Rajasthan the prevalence of disease was first noticed by Lonkar *et al.* (1983).

General outbreak of disease is mostly seen after rainy season mainly between September and November depending on onset of rain. The autumn season is the main breeding season of sheep and by the time this disease occurs, sheep are in early stage of pregnancy i.e., foeti are around 60-90 days. There may be loss in birth weight and congenital abnormalities. Blindness, parrot mouth, breachygnathia, buldged head, micromosia and curved neck. Rams showed aspermia for as long as sixty days.

Rinderpest

Though this disease is not a problem in Rajasthan but it has become a reemerging disease in the coastal areas of Andhra Pradesh.

Symptoms: Sheep occasionally suffer from it. It is characterized by rise in temperature and rapid respiration. The erosions are in the mouth and there is congestion and inflammation of abomasum. The faeces become loose.

Prevention: General hygienic measures should be taken. Fresh purchases should be quarantined. Vaccination should be taken up.

Conjunctivitis

This may affect one or both the eyes of young as well as adult sheep. This disease spreads very fast, if there is some injury of eye (Kaushish, 1992b).

Symptoms: Eyes become red, there is swelling of eyes and lot of lecrymation. Animal may not be able to open its eyes. The outer layer of eyeball becomes white, tears start becoming thick and pus may also appear in tears at later stage. The eyesight is affected.

Sheep becomes all right in 5 weeks.

Treatment: The affected sheep should be kept in darkness. Ten per cent solution of zinc sulphate if put twice a day in affected eye, gives good results. Putting a mixture of sulphacetamide powder (1 part) and boric acid (2 parts) in affected eye, twice a day after cleaning gave encouraging results.

Ecthyma

This is also known as Jadia. It is caused by contagious pustular dermatitis virus causes it. The virus can survive for long under adverse conditions. This is a contagious disease of lambs. It spreads rapidly in humid climate. It can also spread to teats from suckling lambs.

Symptoms: The commisures first become red and then there is pus formation. These become dry and scabs are formed and fall off in 10-15 days.

Prevention: Lorexan, Himax or Penicillin ointment should be applied after removing scabs. Separate the affected animals. Animals can be vaccinated on the underside of thighs by scarification. The vaccine can be prepared by grinding 1 % scabs in glycerine saline (50 per cent) solution.

Foot and mouth disease (F.M.D.)

This disease is wide spread throughout the world. This causes high mortality among exotic sheep than among native sheep. It is highly contagious disease, which affects all the groups. The disease can occur at any time of the year.

Symptoms: The lesions may develop on the upper side of tongue, gums, udder, interdigital spaces,etc., Suckling lambs and newborn may show high mortality due to myocardial involvement. It is followed by salivation, lameness, if not treated there may be maggot formation. The disease may continue from 2-3 weeks to a few months;

Treatment: Affected feet and mouth should be washed with potassium permanganate solution. Boroglycerine should then be applied in mouth and phenyl on affected feet. Affected sheep should be given soft green nutritious grass and given rest.

Prevention: The sheep should be vaccinated every year. The protection against disease is 100 per cent if vaccination is done in time (Bachrach, 1968). Hygienic measures should be taken and sick animals should be isolated.

Sheep pox

It is a very contagious disease of sheep. It affects sheep of all the ages. The mortality rate is higher in lambs than in adults. It deteriorates the quality of hides. The morbidity is high. It spreads by air and by contact.

Symptoms: The disease is characterized by rise in temperature (41.1°C),

eyelids are swollen and there is mucous discharge from nostrils. There are eruptions on non-wooly areas such as nostrils, eyelids, lips, chest, abdomen and mammary glands. There are eruptions in the mouth causing excessive salivation. Lungs may become pneumonic. The lambs may die within a few days of appearance of symptoms (Kaushish, 1992b).

Treatment: Isolate affected animals. Apply antiseptic cream on pustules and give crushed, boiled barley or maize mixed with whey or milk. Bury dead lambs after putting lime.

Prevention: Vaccinate sheep in February/March. They develop immunity in 2-3 weeks.

Rabies

This disease occurs due to a virus, which is present in the saliva of the affected animal. The virus enters the body because of biting by the affected animals. The virus affects the nervous system. The symptoms appear within 14-90 days of biting. This time depends upon the distances of place of biting from brain. Two types of symptoms are observed.

Symptoms: i) Silent form: The animal remains depressed and dies in 1-4 days.

ii) Excited form: Sudden change in behaviour occurs. It becomes excited, runs to bite. There occurs change in voice, lower jaw hangs downward and there is salivation with protruding tongue. This is followed by paralysis. Animal is unable to drink water and dies in 2-4 days.

Treatment: There is no treatment for this disease.

Prevention: If a dog bites, it should not be killed but watched. If it does not die in 10 days, it is not suffering from rabies. Clean the wound with carbolic acid thoroughly. The sheep should be given anti rabies vaccine.

Fungal Diseases

Only three diseases from this group are important from disease point of view. They are:

Mycotic dermatitis

It is caused by *Actinomyces dermationomus.* Smear from the exudate and scabs show branching mycelia and the broader filaments consists of coccid bodies. It is more important in young lambs than in adults. Treat

the animal after shearing with 1:500 copper sulphate or 1:200 Anabae a preparation containing quaternary ammonium compound after shearing.

Ring Worm

Lesions are caused by (*Tricophyton* spp.) on the face, ears and head (rarely on the legs) as circular patches covered with dry grey yellow crusts. Treat cases after softening the crust with soap or oil and apply Tincture Iodine.

Coccidiomycosis

A deep fungus *(Coccidioides immitis)* causing suppurative lesions in the lymph nodes which histologically show granulomatous lesions consisting of double contoured body (may be having radiating clubs). Organisms from the lesions are isolated on artificial media as Cotton white mass having hyphae. It is not a very important condition in sheep as compared with cattle.

Protozoan Diseases

Listeriosis

It is an acute infectious disease of sheep caused by *Listeria monocytogenes* The abortion occurs in the last month of gestation. Lamb dies 2-3 days before abortion. Affected sheep and lambs show nervous symptoms. These protozoans are found in large numbers in placenta, naval cord and uterine discharge. They enter through mouth by eating infected material. This disease is not as severe as brucellosis. This disease affects not more than 7 per cent sheep.

Symptoms: The affected sheep becomes sluggish with conjunctivitis, nasal discharge from one or both nostrils. One ear is dropped indicating paralysis, head is drawn to one side and sheep may move in circles. The temperature may rise to 41.0 ^{0}C in early stages but may fall to 39.0°C. Death may occur in 1-3 days. Recovery is rare. It is a communicable disease of sheep. (Kaushish, 1980).

Prevention: Hygiene is very important to prevent the spread of the disease. Once a sheep has aborted it will not abort for next 2-3 years (Dennis, 1961). There is need to discover preventive measures for controlling Listeriosis which has been recorded by Katiyar (1961 a). Isolate sick animals. Observe sanitary practices. Rodents spread this disease, so they must be killed. Most cases are observed due to silage feeding so this point must be considered. No commercial vaccine is available.

Red water disease

Ticks spread this disease. It is caused by thieleria and babesias. Blood appears in urine. There is high rise in temperature. Injections of Berenil, Bebesan or tripan blue have proved to be very effective. To prevent this disease, sheds should be kept clean and free from ticks.

Coccidiosis

Out of the protozoan infections, coccidiosis is the most important. *Emeriliz arloingi* is the single most significant species causing coccidiosis in sheep.

Symptoms: Lose faeces often thin and watery mixed with blood are observed. Lambs lose appetite and decline to move. The temperature may rise by 1-2° C. The animal becomes weak and dies.

Prevention: The lambs should be stall-fed. As a rule, dry feeds are less likely to cause problem. Treatment with sulphamezathine and nitrofurazone is advocated

Toxoplasmosis

Ovine abortion is caused by *Toxoplasma gondii.* Abortion occurs during the last month of gestation and weak full time lambs may be observed. There may be lesions of focal necrosis on placenta. Diagnosis may be confirmed by observing white necrotic areas on the cotyledons.

Lamb gets infection directly from sheep. Resorption of foetus occurs. This disease affects sheep of young age. Nervous symptoms are noticed. Protozoa are present in placenta.

Prophylaxis: There is no known method of control due to lack of proper epizootology. General, hygienic measures are advised.

Parasitic Diseases

Depending upon the place of their occurrence, they can be classified as external or internal.

External parasites

A number of external parasites are found in sheep. Some of them are harmful but some transmit diseases. The external parasites could be ticks, wingless flies, lices, mites, etc. The first type of external parasites is those, which come to suck blood and leave the host, e.g., ticks and some types of flies. Second types of parasites are those who remain temporarily on the host, e.g., lices and mange mites.

Blood sucking parasites

Ticks: They are important parasites of sheep. They are dark Brown in colour, hairy body with six legs (Soalsby, 1968). On an average, they are 6 mm in length. They suck blood and fall on the ground after engorgement, there they lay eggs. Nymphs hatch out of eggs in 1-3 months. They suck blood and again fall on the ground and become adult in 3-4 weeks time. Ticks are agents for the transmission of disease organisms. The wounds caused can allow invasion by disease organisms. These include looping ill caused by a virus. Tick borne fever caused by one of the *Rickettsia* species, causes abortions and tick pyrexia.

Prevention and treatment: It consists of spraying, dipping or dusting the entire flock at regular intervals. The sheep should be dipped in insecticide suspension for one minute. Normally, it will itself come out by climbing the steps, incase it is not able to come out; it should be helped (Kaushish and Sharma, 1982). The housing area should also be treated. Except in heavily infected flocks, one or two treatments per year will control ticks. Best results are obtained if the animals are treated when the wool is short.

Flies: They are found throughout the world. Their bite is very painful and the affected sheep may stop grazing. They help in spreading some diseases, such as, blue tongue, rift valley fever and sheep ked. The examples of these flies are, Tebanid, Sand flies and some types of mosquitoes. Mellophegus is a blood sucking wingless fly. If present in large numbers, it can cause anaemia and skin irritation.

Temporary parasites

Nasal fly: The fly *Oestrus ovis* is found all over the world. The adult fly deposits larvae near the sheep's nostrils and head. The larvae cause irritation resulting in coughing and sneezing. In severe out breaks, some control can be achieved by treating the sheep to eliminate the larvae in nostrils.

Maggots: Screw worm fly lays eggs around the edge of the wound. They stay in wound from stage I to stage III. The pupae fall on the ground. Ointments containing organo phosphorus compounds are effective in these cases. Dipping in H.C.H. solution gives good results.

Myiasis: It is caused by laying maggots by a particular type of meat eating fly. The repeated strikes by these flies are known as slow fly strike. Heavy losses occur during summer season. Flies of *Lucilia* species cause blow fly attack. Some of the *Calliphora* species can also cause primary attacks. Secondary attacks are caused by *Chrysomyia* species. The blowfly lays its eggs in damp, soiled areas of wool around the hind quarters of

scouring sleep. The larvae burrow into skin and feed on living flesh, the attacks -can be prevented by dipping sheep in long acting insecticides.

Permanent parasites

Lices: These could be of two types, biting and blood sucking. They are flat wingless insects. They lay one egg per day close to the skin. First stage nymph comes out in 10-15 days, which moults into second and third stage and ultimately becomes adult, which starts laying eggs after sucking blood for 3-4 days. It completes its life cycle in 30-45 days. The biting lices are found very close to skin and feed on dandruff, irritation occurs due to biting. Sheep rubs its body against walls and trees. Dipping sheep in H.C.H. or organic phosphorous solution can kill these. This disease spreads by coming in contact with other sheep. Treatment and prevention is same as for ticks.

Mange: These cause great losses of wool. The sheep affected with this parasite may die if not treated. These are very small in size. Female soroptic mites lay eggs deep into the skin, she lays 3-5 eggs per day. The larvae mature in about 17 days. It completes its life cycle in 3-4 weeks. These mites resemble those found in human beings (Mellanby, 1972). Soroptic mange can be found in ears and also on pole (Little John, 1968). These could be of following types:

Sarergetus mange: This affects all the age groups. The sheep rubs the affected parts with feet and teeth. The skin becomes thick and wool dry.

Chorioptic mange: It affects hind feet, which may spread to scrotum and udder. The skin of the affected part becomes red and there may be dry scab formation also.

Soroptic mange: It affects the woollen parts of the body. Sheep bites the affected parts with teeth.

Sinclair, (1949) has discussed about the eradication of sheep scab. Dusting shed with gamexane or slacked lime can control this. The shed can be kept vacant for 10-15 days. Dipping of sheep in lime sulphur solution with nicotine sulphate kills mange mites. Jawahar *et al.* (1976) tried benzyl benzoate and tetraethyl thiuram monosulphide against sorcoptic mange.

Internal parasites

Internal parasites are found in all types of climate. Several species of trematodes, cestodes and nematodes are present in the digestive tract including liver and mesentric channels and other organs of sheep, consequently sheep is said to be a "museum of parasites". There is

nothing more important than control of worms in sheep because these worms interfere in growth of lambs, produce unthrifiness, emaciation and anaemia, loss in production, pave ground for bacterial and viral infections, diminish resistance to other diseases in extreme cases, cause severe mortality in the flocks. Incidences of helminths have been reported from Bihar (Bali, 1973) and Jammu and Kashmir (Bali 1972 a, b; Bali and Fotedor, 1972; Bali *et al.,* 1976). Losses from parasites have been observed more commonly in young sheep than in adults and in areas receiving more than 50 cm rainfall. They result in losses amounting to millions of rupees. (Anon, 1972 b). Morris *et al.* (1977) have reported that the prevention of internal parasites may increase profits by 1,200 per cent. Since these diseases are chronic in nature, they are particularly of economic importance as they cause tremendous waste in maintenance of debilitated animals (Dunn, 1948; Gordon, 1967; Georgi, 1969). Few most important helminthic diseases have been discussed below:

Leaf worms (liver fluke disease)

It is also known as liver fluke disease. It is one of the most serious diseases known to occur in endemic areas. The affected animals showed high rise of temperature with sudden deaths in most of the cases. No other concurrent infections in these animals were found. About 2 per cent sheep and goat slaughtered in Bhubaneswer have lesions in the lungs due to fascioliasis infection. About 50 per cent of these animals did not show corresponding liver infection. Mathur and Dutt (1970) studied the variation of liver fluke egg counts within a day and incidence of infection in sheep and its intermediate snail host. In heavily infected areas, this is one of the most serious diseases and is the major limi ting factor in sheep development. Fascioliasis is also found to be mixed with bacterial infection such as *Clostridium oedimatiens, which may develop,* and the disease is known as "Black disease". *Fasciola gigentica* ranks foremost in undermining the health of our sheep.

Treatment: Corbon tetrachloride is recommended for the control of Fascioliasis. Mathur and Dutt, (1970) studied the treatment of F. *gigentica* infection in sheep and conducted field trials in Himachal Pradesh for control of the disease. Lone *et al.*. (1972) conducted field trials with Trodex and Distodin against fascioliasis in naturally infected sheep.

Control: The control of this disease is important because of the fact that although by treatment there is a reduction in the incidence of infestation, reinfection is difficult to control. Do not allow water to

stagnate. To prevent development of snails, spray such medicines, which kill them in and around ponds. Allow sheep to graze grass grown in the vicinity of ponds only in the afternoon, (Boray, 1969; Ormour, 1972; Over and Dykistra, 1975).

Amphistomiasis

Large number of amphistome species named as parasites of sheep (Hiji, 1935; D'Souza, 1949) are from investigational work undertaken mostly on account of pathogenic significance. *Poramphistomum sp., Cotylophoron sp., Calicophoron sp., Ceylonocotyle sp., Gastrothylaz sp; Ficshoderius sp.* and *Olvoria sp.* have been reported by Bhattachoryulu and Pande, (1969).

Dharmendra Nath (1971) described the detailed incidence of severity of infection of immature amphistomiasis in sheep. The disease occurred from September to March and percentage of mortality was found to be 27.4%. Sharma Deorani (1967) studied the histopathological effects of immature amphistomiasis of sheep. Dharmendra Nath (1971) made observations on allergic skin test for diagnosis of immature amphistomiasis in sheep. Bali and Fotedor, (1972) reported *Poramphistomum jischoedor* from sheep of Jammu and Kashmir. The above authors in the same year studied the morphology of *Poramphistomum* and *Ceylonocotyl* from sheep of Jammu and Kashmir. Bali, (1972a) reported the occurrence of *Calicophoron* in sheep of Jammu and Kashmir. Dharmendra Nath (1971) reported observations on the treatment of amphistomiasis of sheep. In the same year, he also reported the effect of some anathematic against amphistomiasis in experimental infected sheep. Jain and Kamlapur (1971) reported the occurrence of *Calicoporon concorchis* in sheep in India.

Round worms

Several species of nematods and cestods are present in the stomach and intestines of sheep and goat. Consequently, most clinical infections are designated correctly as parasitic gastroenteritis rather than a distinct gastritis or enteritis. There is relatively little information on the number of those parasites required to produce clinical parasitism death.

Dhar and Singh (1970) studied some effects of cortisone administration on the natural and acquired resistance in lamb to the nematode *Oesophagostomum columbianum.* Effect of experimental O. *columbianum* infection has been studied by Sorles (1944). Chellappa and Gopalakrishnan (1977) reported incidences of *Galgeria pachyscellis.* Sheep appeared to suffer more than goats from helminth parasites.

In 1937, 60 ml of copper sulphate solution was suggested as

treatment dose for sheep. Number of anthelmetics was tried in the last two decades with varying results. Hiregoudor (1970) has reported outstanding efficacy of Nilverm (*Tetarmesole*) as an anthelmetic for gastro intestinal nematodiasis in sheep. Fenbendazole has been tried by Kalita *et al.* (1978) and Uppal *et al.* (1977) in sheep. Makkar *et al.* (1974) tried 4 cyano-6-nitro phenol against H. *cantrotus* worms in sheep. Bali *et al.* (1976) and Bali and Singh (1977) tried a new anti cestodial drugs in sheep. They also compared different anthelmentics in sheep and goat nemodiasis. Resistance of H. *cantrotus* against phenothiazine and thiabendazole in sheep has also been reported.

Lung worm infection

Lungworm disease is an enzootic bronchopneumonia due to the presence of the roundworms in the bronchi. The lungworms of sheep are fairly cosmopolitan in distribution. Commonly occurring species in sheep and goats are, *Dictyocaulus filoria; Protostrongylus rufescens; Cystocaulus ocreatus* and *Muilierius capilleris.* Lungworm disease is world wide in distribution but it has been reported from the tropics and from countries where the winters are mild. Exact knowledge is lacking on the prevalence of this disease in different parts of the world but wherever, it is common as a clinical infection it is serious, weather often determines its prevalence in any locality and where it is sporadic a wet season may precipitate a general attack. Lack of systematic data on the lungworm disease in India makes it difficult to assess the magnitude of this problem. However, the work carried out so far indicates that the lungworm infection in sheep is very common. Contribution in this field has been made by Bhatia and Pande (1950). A recent survey in Himachal Pradesh and Jammu and Kashmir has shown that the disease is wide spread and occurs in endemic form causing severe morbidity and high mortality. In a survey in the Garwal hills and in the neighbouring areas, more than 10,000 sheep and 4,400 goats were screened. The rate of infection was around 46% in young lambs and sheep. The heaviest infection has been recorded in animals between 6-12 months of age (Dhar *et al.,* 1972). Westerheim (1937) reported from Norway that in its humid atmosphere, lungworm disease occurs frequently in goats and almost every old animal either harbours parasites or shown injuries caused by them. Genus *Dictyocalus* is of most of economic significance (Poynter and Selway, 1966).

Treatment: (i). Cyanacethydazide: @ 15 mg/kg body weight can be given by sub-cutoneous route. It can be given as a drench @ 17.5 mg/kg body weight. (ii.) Diethylcabamazine : can be given through intra

muscular injections. The dose rate is 40 mg/kg body weight. (iii.) Tetramisole @ 15 mg/kg body weight can be given as drench.

Control: Where clinical disease occurs, animals should be moved from the infected ground to clean pasture. Avoidance of grazing in wet or marshy fields is helpful. Nutrition of the animals appears to play an important role in the incidence and severity of infection. Animals should be well fed. Where lungworm infection in sheep is severe, strategic preventive medicine with cyanacethydrazide or diethylacorbamazine should be attempted.

Tape worms

Several types of tapeworms are found in the intestine of sheep (Table 14.3). Some of them like broad tapeworms *(Moniezia* Sp.), which are lodged in small intestine and can cause blockage. Larval forms of tapeworms, called bladder worms, may cause severe damage in sheep. The larval form of *Taenia multiceps* is lodged in the brain and spinal cord of sheep and cause gid. Sheep moves blindly in circles. Regular dosing of dogs against causative tapeworms can prevent this disease. Adult tapeworms may reach a length of 2-4 meters. Their segments are shed with dung balls. Gravid mites found in pastures become infected by eating these eggs. Sheep picks up infection by eating these mites. They take 30–40 days to develop in sheep. They are found in large numbers in hoggets. Increase in numbers of tapeworms affects the growth rate of lambs (Soulsby, 1965). Common anthelmintics are given in Table 14.4.

Table 14.3. Common tapeworms found in sheep

Name	Common name	Place where found
Avitalina stripetata	Tape worm	Small intestine
Echinococus cyst	Hydrated worm	Liver and lungs
Helictometra giardi	Tape worm	Small intestine
Monezia expansa	Tape worm	Small intestine
Cysticercus ovis	Sheep muscles	Heart and muscles

Miscellaneous Diseases

Choking

It occurs due to the eating of mango seed or clothes. Sheep moves with head side ways and stops eating. If it drinks water, it comes out through nostrils. As soon as choking is observed, sheep should be given

Table 14.4. Common Anthelminitics

Name of Anthelmintic	Dose	Method of giving	Remarks
Nicotine + Copper sulpate solution	30-40 ml / adult sheep tea decoction	Drench	If poisoning symptoms appear give
Dicestol		As drench or electuary, tablet can be swallowed.	For tape worms
Corbon tetra chloride	1-3 ml adult sheep	As drench mixed with whey or liquid paraffin	Effective against liver flukes.
Hexachlorethane	0.2 g/kg body weight	Given through stomach tube.	Effective against flukes and stomach worms.
Hexachlarethane	0.015-0.02 g/kg body weight	Given as drench	Effective against round and tape worms.
Nilverm		Given as drench	It is a broad spectrum anthelmintic
Piperazine adepate	4-8 g/adult sheep depending upon weight	Mixed with feed, can be given as a drench	Most effective against ascoris and nodulor worms.
Phenothiazine	5-15 g	Given as drench	Effective against strongyles.
Thiabendazol	0.05-0.1 g/kg body weight	Given as drench	Very effective against strongyles and other stomach worms.

water to drink, so that the choking material goes into rumen. If it does not succeed, operation of oesophagus is the only solution.

Constipation

It can occur due to over eating or diseases of intestine. The dung comes out in small quantity at a time. It may be dry covered with mucous. Sheep becomes lazy and stops grazing. Giving anemia with luke warm soap water relieves the symptoms.

Diarrhoea

This may occur due to indigestion or giving strong medicines. It may also occur due to some protozoon diseases. The hindquarters may be soiled with loose faeces and rumen may appear to be empty. Such sheep should be given barley water. Sheep can be given opium, katechu or kaoline but sheep should be given 750 ml linseed oil before giving medicine.

Injuries

Injuries can occur on any part of the body due to sharp objects. Efforts should be made to check haemorrhage. The wound should be cleaned with weak potassium permanganate solution or some dilute antiseptic solution such as dettol or savelon can be used for this purpose. Then some antiseptic ointment can be applied.

Dystocia

It may be due to foetal or maternal causes. It may result due to abnormal presentation of lambs. Sometimes mating small sized ewes with bigger rams also results in dystocia, it may be due to oversized foetus. Maternal dystocia is more frequent in primiparous animals. A veterinarian may be consulted.

Mastitis

It occurs due to retention of milk, injury and inflammation of udder and teat. *Pasteurella haemolytica* and *Staphylococcus aureus* were recorded in 33.3 and 53.3 per cent cases of mastitis milk (Das Kornel, 1992). The udder should be emptied and hot water fomentation should be done. If there is injury it should be cleaned with weak antiseptic solution and some ointment be applied. If it is due to bacterial infection, then intramammary antibiotic can be given.

Retention of placenta

Failure of placenta to be expelled during third stage of parturition

is a common problem. It is associated with asynchrony of endocrine mechanism, dystocia, uterine inertia, twinning and induction of parturition with dexamethasone. It may occur in abortions also. There may be pus formation in the uterus. Yellow foul smelling discharge may come out of uterus. Normally placenta comes out itself in 6-12 hr. If is takes maritime, some antibiotic may have to be kept in the uterus.

Metritis

It is inflammation of the womb. It does not occur before lambing, unless the lamb is dead. It occurs within a few days of lambing, especially if lambing is assisted, retained, or incomplete lambing. It is characterized by slowly developing feverishness to point of acute misery and collapse, usually with increasingly foul-smelling discharge from the vulva. Intra uterine treatment with Antibiotics is very effective.

Tympany: It is also called bloat or hoven. It occurs due to eating of green leguminous fodder. The left flank becomes distended; on striking with a hand it gives sound of drum. To prevent it animal should be allowed limited grazing on rich pastures. It case of tympany animal should be given 50 ml turpentine oil in 200 ml whey or sweet oil. The animal showed be walked. If there is no relief puncture can be made with trocar and cannula in left flank. Tying a "stick" in the mouth as a bit is most practical.

Intussuception

It is rather of a common occurrence in sheep due to several reasons, i.e., nodular worms, change in feed, local intestinal lesions. The animal looks dull, off feed, kicking at the belly with no rise in temperature and frequent straining with no defecation, an excitement with symptom of colic at later stage and the animal becomes recumbent and dies. No rational treatment except surgery. Mild purgatives with astringents may be of little use.

Drenching pneumonia

It is one of the most common and important pathological conditions in sheep. It is characterized clinically by increased respiration, coughing and abdominal breathing. Occasionally, one can come across 'Aspiration' or "drenching" pneumonia during mass drenching operation. Avoid forced drenching and allow the animal to deglutinate the drench itself. If some fluid has entered in respiratory tract, lower the animal's head immediately and slap few times on its head.

Acute Impaction of the Rumen

The ingestion of large quantities of highly fermentable, carbohydrate feeds cause an acute illness due to the excess production of lactic acid in the rumen. Clinically, the disease is manifested by dehydration, blindness, recumbence, complete ruminal stasis and a high mortality rate. Antihistamine such as Avil, normal saline solution 500 ml I/V and soda bicarbonate 4 g orally will help.

Poisoning

Generally speaking, sheep are fairly immune to semi-poisonous plants if on free range with plenty of variety; but there comes a time when forage is scarce.

The principle is the same in all cases. First remove the sheep from the poison, then the poison from the sheep. Having removed the sheep from the poisonous shrub, food bin or whatever; house her in a warm place covered with a rug and if extremities are cold, massage and surround with covered hot-water bottles. Give a purge or emetic, generally Epsom salts. The next stage is the antidote to neutralize the poison, followed by stimulants, or whatever is necessary to heal the damaged tissues. Chlorodyne 2.5ml for an adult sheep should be at hand and given if pain is acute. Treatment of shock is vitally important; extremities tend to get cold while the system works overtime ridding itself of the poison. Strong, sweet black tea or coffee stimulates and counteracts shock but it must be strong.

A linseed-oil drench is frequently advisable as a follow-up measure to offset the caustic effects of Epsom salts. Dosage varies from 170 to 280 ml or more, depending on severity of poisoning and size of animal. Small soft-drink bottles are convenient for administering this.

After treatment consists of bran and molasses mashes; no concentrates at all; hay fresh water offered or changed frequently. Special indications for particular vegetable and mineral poisons and for overeating of concentrates in a raid on the food store are as follows.

Chlorinated Hydrocarbon insecticides: This group includes benzene hexachloride (BHC), its pure gamma isomer Lindane, aldrin, dieldrin, chlormone, toxaphone, methoychlor, isodrin and heptachlor, etc. They are used extensively as insecticides to control external parasites on sheep or to control insect infestation ingestion, aspiration and percutoneous absorption are possible portals of entry into the body. Most of the insecticides accumulate in the fat depots, may be excreted in the milk in dangerous amounts. The toxic effects produced include increased excitability and irritability, followed by muscle tremors, weakness and

paralysis and terminal convulsions in severe cases, salivation and teeth grinding is noticed. Complete anorexia occurs.

Organophosphorus insecticides: The group includes some of the most dangerous chemicals which are highly toxic, but are used and recommended for the control of insects attacking plants, available for control of internal parasites of sheep. Some of the compounds are Corbophenthion, Demton, Daznon, Dimethylaporation. As anthelmintics Rueleam (Asuntol), Coral (Bayer) and Neguvon (Bayer), have been used. The clinical signs of poisoning are profuse salivation, muscle stiffness, dyspnoea, with open mouth breathing, diarrhoea and muscular tremors. Atropine sulphate 2.0 mg/kg body weight; 1/3 to be given I/V in 10 ml distilled water and rest S /C.

Snakebite: Venomnous snakes fall into 2 classes: the alpine snakes which include cobra and the vilerino snakes, which comprise russels viper. Alpine snakes have short fangs and tend to chew their victims. Their venom is neurotoxic and kills the victim by paralyzing the respiratory centers. Viperine snakes attack once and then withdraw. Their venoms mainly haemolytic causing pronounced local damage. If antivenin is not available and the bite is located in an area where tourniquets cannot be applied, excision of an area of skin, 7 cm in diameter is done. No treatment is possible due to sudden bite in grazing areas.

Electrocution: One of the natural calamities where death ensues in few seconds. Short circuit in electric line, leakage of current in wire fencing are its causes. It should be very well differentiated from lightening stroke because there was no evidence of lightening fall and moreover there were no signs of scorching and singing of skin and hairs on the body of the animals.

Acetonaemia: It usually occures within 2-3 weeks of lambing. The sheep goes off eating concentrates; may continue to eat roughage, irregular cudding and droppings become dark, covered in sticky mucus. There is no fever. Correct feeding can prevent the disease. Ensure enough energy. Give cobaltized salt for 10 days; increase roughage; injection of glucocorticosteroid will stimulate appetite, 225 g flaked maize, night and morning will probably help.

Blindness (contagious ophthalmia): Germs of the disease are spread by flies, but also carried from infected eyes to healthy eyes by the tips of flapping ears, while sheep are feeding at trough. Usually more cases in a flock are observed. One or both the eyes become watery cornea becomes cloudy white spot develops at cornea. Spot enlarges, becomes

reddened and may rupture, causing loss of the eyeball. Opthalmic ointment or antibiotic powder in eye is commonly used. Best treatment would seem to be subconjunctival injection of antibiotic-long-acting penicillin possibly best.

Colic: It is very common in young stock conditions favouring worm infestation excessive feeding of concentrates, access to cold water immediately after concentrate feed; after swallowing bottle teat after poisoning. There occurs spasmodic pain in the digestive tract; sighs and groans, goes down again, suddenly stops eating and looks anxiously, tympany of the left flank increases distress leading to death if unchecked. To prevent colic, correct feeding and constant access to water; feed the flock roughages together; hold the teat when bottle feeding. Three hundred ml of linseed oil (for adults, less for kids), followed by 1 glass of water, repeated hourly until pain subsides.

Cuts and Wounds: All cuts but the very small are best stitched, as this reduces the healing time. Most cuts are contaminated to some extent and this both delays healing and provoke the sheep to attack the wound, further delaying healing. Antibiotics reduce the infection, which accompanies contamination and speed healing. Tetanus antiserum is also indicated, unless the sheep is vaccinated. A local or general anesthetic may be needed for the cleansing and suturing of large wounds. Cuts on the udder or teat exposing the teat must be stitched. Intramammary penicillin injection (both sides) is indicated to prevent the development of mastitis.

Eczema: Several forms of skin diseases occur in sheep, two of which have the appearance of eczema. *Contagious Pustular Dermatitis (Orf):* A local infection of sheep. Young animals most frequently affected; but all ages liable on first contact with infection. Pimples appear about the nose and mouth, less often about the eyes, anus and hoofs, turning to watery blisters; then to sticky and encrusted scabs. They also on udder of suckling sheep. Vaccine will give protection. Dress wounds with gentian violet.

Fractures: A fracture (if skin not broken) below elbow or fore leg below hock or hind leg can usually be treated by using plaster of Paris depending on value of the animal. Surgery may be successful in other cases.

Lice: It is a very contagious disease of sheep in poor condition, especially those with little access to open air and to rainfall. There is skin irritation; rubbing, scratching etc.; bald patches, lice are seen on skin. Dust with B.H.C. powder; or wash weekly for 3-4 weeks with Derris or B.H.C.; or single bath with organophosphorous insecticide.

This will control ticks and mange mites as well. Regular treatment is essential for prevention of disease.

Louping Ill: It occurs on tick-infested pastures during the period of tick activity. Home-bred young stock are only slightly affected, seldom developing the nervous symptoms; home-bred adults are very seldom affected at all; newcomers of all ages are liable to serious infection during the first tick season. There is dullness and fever, followed by tremor, muscular spasms and bewildered gait; followed often by collapse, paralysis and death. Homebred stocks develop natural immunity. In-bought stock from a tick-free area should be inoculated with 5 ml louping ill vaccine in their first year. Shelter and quiet and careful nursing, will often save the patient. The presence of a congenial companion in the sick shed is helpful.

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15.
Nutrition

Sheep can eat many types of fodders, grains and cakes. It can also eat some types of shrubs and leaves of a variety of tree species. Samples of a variety of fodders eaten by sheep have been collected by Maheshwari and Talpatra (1967). They took samples from oesophagus and ruminal fistulae. A sheep eats about 800-1200 g of fodder on dry matter basis daily.

Sheep is able to meet throughout the year, all its requirements of nutrients from grasslands, except during winter season. Only phosphorus requirement cannot be met from the pastures (Joshi and Ludri, 1970).

Protein and energy are essential for weight gain and better production. The ratio between protein and energy contents is essential for their better utilization (Shukla and Pal, 1972). Researches have been conducted on protein requirements of rams and ewes by several workers (Singh and Mahadevan, 1968,1969,1970). Body weight of sheep increases if, they are given 250-450 g of concentrate mixture (Khot *et al.,* 1962). Fifty per cent increase in body weights have been observed in Malpura sheep if they are given 400g of concentrate mixture in addition to grazing (Bhatia *et al.,* 1971; Patnayak *et al.,* 1971). Semen quality deteriorated when sheep were fed cowpea up to one and a half year (Honmode *et al.,* 1971d).

The major advantage of sheep in agricultural production system is their special ability to utilize, mostly natural grasses, crop stubbIes, tree loppings and to some extent, bushes to produce saleable products, e.g. meat, wool, pelts, skins, etc. Sheep are selective grazers preferring short and low set grasses, legumes and a wide variety of low forbes and thus do not compete with goats and cattle which mostly utilize shrubs and bushes and tall grasses, respectively. They can utilize very sparce and low set vegetation because of extremely close grazing nature. This is possible because of clefted upper lip, thus waste land or marginal and sub marginal land can be profitably utilized for sheep production. However, large areas, which should receive attention for improvement in this manner, are now being put under crop production. The density of

livestock per unit grazing area has greatly increased due to an increase in the livestock population and shrinkage of grazing lands. Practically a little or no supplemental feeding is provided to sheep. The principal role of sheep is, therefore, as a grazing animal and the aim of efficient sheep production should be to maximise output of pasture and natural range lands with some supplementation with conserved fodders and agro industrial byproducts, except in very highly specialized production systems, e.g. fat lamb production, where certain percentage of feed would have to contain cereals, oil cakes, brans, etc.

Nutrient Requirement of Sheep

Sheep are reared for wool and mutton purposes. A good, pasture may fulfill the maintenance requirement of sheep. The need for extra nutrient arises when pasture is poor. The word nutrient means the component of feed, fodder or feeding stuff, which supports the animal's body. To maintain health and productivity of sheep, "Balanced ration" is essential. In the balanced ration, all the essential nutrients are found in adequate quantity and proportion. The nutrients are protein, carbohydrate, fats, minerals, vitamins and water (Table 15.1 and 15.5). Deficiency of any of these nutrients will result in deficiency diseases. Protein, fat and carbohydrates are known as macronutrients while minerals and vitamins are known as micronutrients, because they are required by sheep in very small quantities. The energy, i.e. Total Digestible Nutrient (TDN) requirement is 1-3 kg/100 kg body weight. The requirement of protein energy increases during stress, i.e., lactation, breeding, etc.

Nutritional Requirements of Sheep

The nutritional requirements of sheep have to be met through the available feed resources by adopting scientific feeding practices that will largely overcome the common constraints (Table 15.1). Work on nutrient requirements of sheep in this country is far from comprehensive and therefore, separate feeding standards for sheep have not yet been developed.

NRC standards for lambs, start from a body weight of 27 kg, whereas, the adult body weight of most sheep breeds of our country is about 30 kg or less. Ranjhan (1980) has tabulated (Table 15.7 and 15.8) the nutrient requirements for lower body weights, which are essentially based on extrapolation of ARC and NRC recommendations. There is an urgent need to work out the requirements of various nutrients under our conditions and to lay down uniform feeding standards.

Studies have shown that about 2 litres of water is required per sheep/day during winter and 3.5 to 4.0 litres during summer. This requirement would further increase if the animals have to walk long

Table 15.1. Nutrient requirements of a sheep weighing 35 kg

Nutrient	Daily requirement
Total dry matter	900 g
TDN	450 g
DCP	45 g
Calcium	2.4 g
Manganese	1.0 g
Magnesium	1.2g
Phosphorus	1.2 g
Common Salt	5.0 g
Potassium	4.2 g
Sulphur	1.5 g
Copper	8.0 mg
Cobalt	0.2 mg
Zinc	75mg
Iron	60.0 mg
Iodine	30.0 mg
Selenium	0.1mg
Molybdenum	0.1 mg
Carotene	1.5 mg
VII. A	750.0 i.u.
VIT. D	200 i.u.

distances. In general, an adult sheep should consume feed from 2.5 to 3.0% of its body weight for its maintenance, whereas, a growing lamb should consume 4 to 5% of its body weight to show adequate growth. Energy is the most important nutrient on which the requirement for other nutrients depends. Joshi and Ludri (1970) found 1.3 kg /100kg body weight as the minimum amount of TDN required. Gill and Negi (1971) recommended 809 g of DM and 401 g of TDN per day for maintenance of rams averaging 30 kg live weight. Bhatia *et al.* (1978) found that the grazing rams consumed 343 to 766 g TDN in different months without loss of body weight. Singh *et al.* (1979) recommended 30 g TDN and 5 g of DCP per kg metabolic weight for maintenance of the ewes and optimum wool production. Patnayak *et al.* (1979) observed 397 g TDN and 34g DCP could maintain rams weighing about 32 kg. All these results indicate that for adult ewes, approximately 10 g TDN are required per kg live weight for maintenance and wool production. It appears that weaner lambs can consume 400 to 650 g TDN / day and gain on an average, 50 to 150g/ day. For obtaining optimum growth in weaner lambs of about 150g/ day, atleast three times the

maintenance requirement, about 30 g TDN per kg live weight of lamb, is needed.

The optimum ratio between DCP and TDN energy consumption in adult sheep is 1:10, whereas, for grazing lambs, it is 1:8.5 to 9.0 (Maheshwari, 1977). Gill and Negi, (1971) found that 23 g of DCP was required for a ram weighing 30 kg, but Singh and Mahadevan, (1970) reported that the minimum DCP requirement for maintenance was 12.1g / day for a ram weighing 35kg. Recently, Pachauri and Negi (1979) working on Gaddi ewes reported that 23 g of DCP was required by a 20 kg ewe to maintain nitrogen balance. Grazing studies conducted at Central Sheep and Wool Research Institute, Arid Region Campus, Bikaner, have shown very low level of DCP intake (7 to 9 g/ day) by Marwari ewes for maintaining their body weight. Mathur, (1973) found that up to 10 months of age, 13 per cent of crude protein in the diet was adequate and from 10 to 16 months of age, 10 per cent crude protein in the diet was found adequate. The approximate requirement of DCP for maintenance appears to be 1 g or a little less per kilogram live weight. Mahadevan (1961) reported that 6.7 g of calcium and 6.0 g of phosphorus and 25 mg of carotenes are required per day for a sheep weighing 30 kg. Nutritional requirements of sheep in relation to certain nutritional diseases have also been reported and it is indicated that vitamins and minerals, particularly trace elements, should be properly supplemented.

Feed Resources

Sheep will have to depend mainly on stubble grazing, crop residues, tree leaves and agro-industrial byproducts, because it may not be possible to spare any cultivable land for sheep grazing in times to come. Shrubs and grasses with a few trees dominate the natural rangelands. Among the bushes, *Ziziphus* species is very common. These lands can be improved by protecting them from biotic factors and reseeding with perennial and high yielding grasses and legumes. Technologies have been evolved for establishing perennial grasses and legumes, etc. introduction of fodder legumes as inter-crops in rain fed cereal crops and raising the fodder resources through silvipastoral practices. The availability of dry matter from tree leaves in the country has not been assessed but it is roughly estimated that 60% of the feed available to sheep and goats come from top feeds alone. The most common fodder trees available in the grazing lands in arid areas are Khejri *(Prosopis cineraria),* Kankera *(Gymnospora spinosa),* Babool *(Acacia* spp) and Neem *(Azadirachta indica),* etc.

Feeding management of top feed resources has to be geared not only

to the increased nutrient availability and preservation of sources but also to the applied feasibility and economics. It will thus be necessary to workout the relative efficiencies of the various practices of harvesting and utilisation, in terms of their actual nutritive values coupled with cost benefit ratios.

Water

Water is more vital for the maintenance of the animal's life than any other feed component. It is the main constituent of all body tissues and the excretion of waste products through faeces and urine. The body water plays an important role in the animal's regulatory mechanism. The water in the feed usually satisfies most of the water requirement during the season when green feed is available and not much water is consumed by sheep. Water intake consideration is highly correlated with both air temperature and absolute humidity. Water requirement increases with growth, gestation and lactation and when sheep are subjected to heat stress or when salt content of the diet is more or they are made to travel long distances. On dry feed, an adult sheep will require about 2 litre water per day during winter and 3.5 to 4 litre during summer. Normally, sheep will drink approximately 2 to 3 litres of water for every kg of dry feed consumed. Sheep in desert areas can stand water deprivation upto 3 days. However, watering, free choice every alternate day has been found to have no deleterious effect. Sheep can also tolerate salt content up to 1 per cent in the drinking water.

Energy

The soluble carbohydrates, fibers, fats and oils available in the feed have a common function of supplying energy. The energy feeds are to the animal what diesel is to a tractor, a source of energy and are used to supply heat to keep the body warm, to provide energy for physical activities and other life processes and to help growth, reproduction and milk production. The carbohydrates are also required for the growth and development of rumen microorganisms. Lack of energy is the most common nutrient deficiency in sheep and may result from lack of feed consumption or because of low feed quality. In general, adult ewes consume dry matter @ 2.5 to 3 per cent of their body weight, both under stall-feeding and grazing conditions. Lambs achieve satisfactory growth rate at dry matter intake level of 4 to 5 per cent of body weight. Different systems are in vogue all over the world to express the energy requirements. In India, the total digestible nutrients based system is in practice. In recent times, metabolizable energy (ME) based system is also being followed. The percent TDN requirements of lambs are higher than

adult sheep. Similarly the pregnant, nonlactating ewe, requires 1.0 kg of TDN per 100 kg live weight for maintenance and wool production. This requirement would be about 50 per cent more during first 10 weeks of lactation. The deficeincy of energy in the diet of sheep may result in reproductive failure, poor growth and loss of body weight. The progressive decrease in body weight may ultimately lead to death. The dry matter should contain about 50-55 per cent TDN for adults and 60-65 per cent for growing lambs.

Protein

Protein is the basic structural material of all the body tissues. This includes the muscles, nerves, skin, connective tissues and vital organs, but also the blood cells, animal's hair/wool, hooves and horns. Since all the living tissues are in a dynamic state and are undergoing constant wear and tear, protein is essentially required for their regeneration. Thus, proteins are essential for growth and development of the body (Table 15.3). The breeding animals need protein for prenatal growth and development of the foetus and to produce milk for postnatal growth and development of young ones. Clean scoured wool is almost pure protein in the form of keratin. If the ration does not contain enough energy, the protein that might be otherwise used for maintenance, growth and production, will be used as energy, source. But, protein cannot be replaced by any other nutrient in the ration. Protein deficiency results, in reduced appetite and feed intake and poor feed efficiency. This in turn results in poor growth and development of muscles as well as reduced productive efficiency and wool production directly as well as through lowered secretion of hormones. The animals on low protein feed have lower disease resistance. The lambs require more protein than mature ewes (Table 15.2). It is higher during breeding, later part of pregnancy and lactation than during other periods.

The present trend in other countries is to express the crude protein requirements for ruminants in terms of digestible crude protein only. Under Indian conditions, it may not, however be applicable because of many unconventional feeds being used which have very low digestibility of protein, although the crude protein content is reasonably high, tree leaves are such an example. The approximate daily requirement of DCP for maintenance is 1/10th of the TDN or 1 g for every kg live weight. This requirement will increase by about 50 per cent during pregnancy and by 100 per cent during lactation and growth. A 30 kg sheep will thus require 30 g DCP during dry non-pregnant stage, 45 g during last 6 weeks of gestation and 60 g during first 10 weeks of lactation. Protein quantity is more important than

Table 15.2. Energy and protein requirements at different body weights of lambs

Attributes	Body weight (kg)		
	11	15	25
Age group (months)	3-6	6-9	9-12
Daily gain (g)	41	79	97
DM consumed (g)	495	656	990
TDN consumed (g)	346	458	675
DCP consumed (g)	44	59	74
DM/gain	12.1	8.3	10.2
TDN/gain	8.4	5.8	6.%
TDN/DCP	7.9	7.8	9.1
DE consumed (Kcal)	1,522	2,015	2,970
ME consumed (Kcal)	1,218	1,612	2,376
GDCP/TIME	36.12	36.60	31.14
Kg DM/ 100 kg	4.5	4.4	3.96
KgTDN/l00 kg	3.1	3.05	2.7
gDCP/l00kg	400	393.3	296

Source: Maheshwari, 1977

quality in the sheep ration because the microbial action in the rumen will convert low quality amino acids although the availability of some sulphur containing amino acids, e.g., methionine and cystine could become limiting factor in wool sheep.

Table 15.3. Digestible crude protein (DCP) and total digestible nutrient (TDN) requirement (g/ day) for maintenance and growth of lambs

Body wt.	Maintenance weight gain									
(Kg)			50 g/ day		100g/day		150 g/ day		200g/day	
	DCP	TDN	DCP	TDN	DCP	TDN	DCP	TDN	DCP	TDN
5	10	120	15	150	20	210	25	250	30	300
10	16	168	20	211	25	254	30	296	35	339
15	21	222	28	279	34	335	40	391	47	447
20	26	271	34	340	42	408	50	477	58	546
25	31	330	41	414	50	497	59	581	69	664
30	36	374	47	469	57	564	68	658	79	753
35	40	425	52	476	64	640	76	747	89	855
40	44	474	58	594	71	714	84	834	98	954

Minerals

When a feedstuff is burnt, a white ash is left. This contains minerals. The minerals are used for a number of different purposes. Their greatest use is in the building and maintenance of the skeleton and teeth. They also provide acidic and alkaline reactions to digestive juices and play an important role in digestion. Minerals are also helpful for the maintenance of osmotic pressure in different body fluids. They are also used in wool growth, as the wool proteins contain sulphur. Thus availability of a number of minerals in the diet of sheep is essential (Table 15.4). If one or more of these minerals are deficient in the diet, the animals will ultimately exhibit clinical symptoms of deficiency. The role of the minerals in sheep nutrition is complicated because excess of some of them may result in poor feed intake and digestion, hamper utilization of other minerals and can even cause toxicity.

Table 15.4. Approximate concentration of essential macro and microelements in the animal body.

Macro element	Percentage	Micro element	mg/kg
Magnesium	0.04	Chromium	0.08
Chlorine	0.11	Cobalt	0.02-0.10
Sulphur	0.15	Manganese	0.2-0.5
Sodium	0.16	Iodine	0.3—0.6
Potassium	0.20	Selenium	1.7
Phosphorus	1.00	Molybdenum	1.4
Calcium	1.50	Copper	1.5
		Zinc	10-15
		Iron	20-80

Many deficiencies result in anorexia (reduced appetite), reduced gain or loss in body weight, unthriftiness, abnormal hair/wool coat, dullness of skin, bone deformation and staggered gait. Calcium and phosphorus are necessary for bone formation and its maintenance. Rickets indicates deficiencies of these minerals in young ones and osteoporesis in adults. Deficiency of copper and cobalt may result in tetany and in doggy wool. Selenium deficiency may lead to 'White muscle' disease in lambs. Sulphur is present in wool and hair. Inadequate supply of iron, copper and cobalt results in anemia and deficiency of iodine in goiter (Table 15.5).

Until 1959, 16 mineral elements were considered as essential, which comprised macro-elements: calcium, phosphorus, potassium, sodium, chlorine, sulphur, magnesium and the trace elements: copper, cobalt, chromium, iron, iodine, manganese, molybdenum, selenium and zinc.

Table 15.5. Requirements for different nutrients for maintenance of an adult sheep weighing 35 kg

Nutrient*	Requirement/ day	Nutrient	Requirement/ day
Total feed	900g	Cobalt	0.2mg
T.D.N.	450g	Zinc	75mg
D.C.P.	45g	Iron	60mg
Calcium	2.4 g	Manganese	30mg
Phosphorus	2.0g	Iodine	0.1mg
Magnesium	1.2g	Molybdenum	1.5 mg
Common salt	5.0g	Selenium	0.1mg
Potassium	4.5 g	Carotene	1.5 mg
Sulpher	1.5 g	Vitamin A	750 IU
Copper	8.0mg	Vitamin D	200 IU

* Air dry basis

Some evidence is available from feeding trials that bromine, barium and tin can give better growth responses, put conclusive proof of the essential role of these elements is still lacking.

All the essential elements are believed to have one or more catalytic functions in the cell. Sodium, potassium and chlorine have electrochemical function and are concerned with the maintenance of acid base balance and the osmotic control of water distribution within the body. Calcium and phosphorus are essential parts of skeleton. Sulphur is necessary for the synthesis of structural proteins. Magnesium functions catalytically, electrochemically and structurally. Iron is important as a constituent of haemoglobin, cobalt a component of vitamin B-12 and iodine forms a part of thyroxin hormone.

Major elements

Calcium: About 99% of the total calcium found in body is present in skeleton and teeth. It is also an essential constituent of living cells and tissue fluids. It is essential for the action of some enzymes and for contractile properties of muscles. It plays role in the coagulation of blood. Its concentration in plasma varies between 8 and 11 mg per 100 ml. Calcium is found in leguminous crops and in green leaf crops, but cereals and roots are poor sources. Fishmeal, bone meal and meat meal are excellent sources of calcium.

Phosphorus: It is present in bones, phosphoproteins, nucleic acids and phospholipids. Eighty percent of the body phosphorus is found in bones. The serum phosphorus concentration varies from 4 to 10 mg per 100 mI. Fishmeal, cereal grains and meat are its good sources.

Phosphorus is present in the form of phytates in cereal grains, which is hydrolysed by bacterial phytases in the rumen of sheep.

Diseases of bones are common in sheep. The bones may become soft and weak. Rickets is a common disease of lambs. Giving Vit.D can treat these. Injections and by feeding wheat bran (Chakrabarti *et al.,* 1975; Clarck *et al.,* 1975; Fitch, 1954).

Kidney stones are formed of calcium oxalate, carbonate or phosphate, silica or magnesium, ammonium phosphate. These can be present in kidney or urinary bladder and cause obstruction in urinary passage. This disease is prevalent in areas, where, there is very hot or cold climate and lot of sweating. This disease occurs due to imbalance of calcium, phosphorus or magnesium contents in ration or due to deficiency of sodium and potassium. There is frequent micturition, pain in kidney area. If diagnosed at an early stage, it can be removed surgically, (Field, 1969; Mc Intosh, 1978).

Sodium: Major part of body sodium is present in body fluids and soft tissues. It is concerned with acid base balance and maintenance of osmotic pressure of body fluids. Much of it is present in extra cellular fluid. Most of the straws are deficient in sodium. Meat meal and fishmeal are richer sources. Its higher concentration in water (1.3 per cent) may result in dysentery (Smith and Gawthorn, 1975).

Potassium: It plays important role in the regulation of osmotic pressure. It is mostly found inside the cells. It plays an important role in nerve and muscle excitability and plays role in carbohydrate metabolism. If potassium is absorbed in excess in body, it is excreted in urine. Excess absorption of potassium interferes with the metabolism of magnesium, which may result in hypomagnesaemia tetany.

Chlorine: Like sodium and potassium, it also plays role in acid base balance and osmosis. It is present in gastric secretions as hydrochloric acid as well as chloride salts. It is excreted in urine as well as in sweat as sodium chloride. It is present in fish and meat meal. The chlorine content of pasture may vary from 30 to 340 ppm.

Sulphur: It is present in cystine, cysteine and methionine. It is part of biotine and thiamine vitamins and insulin hormone. Sheep wool contains sulphur, hence the sulphur requirement is very high. Animals get sufficient amount of sulphur if they are getting enough protein in diet. Its deficiency may result, if protein source is replaced by urea as a partial nitrogen replacement, sulphur may be limiting factor for the synthesis of cysteine, cystine and methionine. The sulphur requirement increases if the diet of sheep is substituted with proteinous nitrogen.

Magnesium: About 70% of total body magnesium is found in the skeleton. The remainder is distributed in fluids and soft tissues. It is catalyst for phosphate transefrases, decarboxylases and acyltransferases. It is closely associated with phosphorus and calcium. It is present in wheat bran, cotton seed cake and linseed cake, etc. The magnesium content of forages vary widely. The daily prophylactic dose for hypo magnesia in sheep is 7g.

Trace elements

The essential trace elements are copper, cobalt, iron, zinc, iodine, sulphur and manganese. In addition are few which are considered as probably essential elements like, chromium and nickel. Besides these, there are few toxic elements, which are also found in water and soil such as molybdenum, arsenic, fluorine, lead etc. The minerals that need consideration in feeding sheep are common salt, calcium, phosphorus, copper, etc.

Copper: It is an essential component of the mature red blood cells. Copper is present in several enzymes, whose role ranges from utilization of iron to the pigmentation of skin. Some of the enzymes are cerailoplasmin, cytochrome oxidase, lysine oxidase, tyrosinara plastocyranin and haemocynin. This element is essential for normal augmentation of hair, fur and wool. In sheep, a disease called swayback, is related to its deficiency. The symptoms are that the lambs are born to apparently healthy ewes with some degree of ataxia. Some lambs are unable to stand; some will rise and fall backwards while some lambs show slight weakness of hindquarters. Another deficiency symptom of this element is "steely wool" or "stringy wool". In this condition wool loses its crimps because of copper deficiency. Deficient ewes come in heat late, there may be paralysis of hind quarters. Deficiency occurs, if it is less than 5ppm in soil. The optimum requirement of copper for sheep is 5mg/ day. The salt licks containing 0.25 to 0.5% copper sulphate have been found to be effective in grazing sheep.

The copper salts in high doses are toxic as copper can act as cumulative poison and sheep are particularly very susceptible to copper sulphate poisoning. Chronic copper poisoning in sheep has been reported under natural conditions in some countries. If due to accident, sheep eats copper salt, it may result in toxicity. The liver concentration in such cases may go up to 0.8 per cent (Marston, 1952; Allcroft, 1963; Smith and Gawthom, 1975). Liver is the storehouse of body for copper element. Its concentration in sheep liver is 0.01 to 0.04 per cent and in blood it is 0.007 and 0.012 per cent. Copper is widely distributed in

foods. Seeds and seed byproducts are usually rich in copper, straws contain little copper. Milk is also a poor source of this element.

Cobalt: A deficiency of cobalt in the soil is reflected in a deficiency in herbage and sheep grazing such pasture develop deficiency 'Pine'. The cobalt is a part of vitamin-B and is present in enzymes involved in the synthesis of RNA and the metabolism of amino acids. Deficiency of cobalt leads to insufficient production of B-12. Therefore, cobalt deficiency symptoms are actually B-I2 deficiency symptoms. Cobalt sulphate and cobalt chloride are good sources of cobalt. Drenching with an aqueous solution of cobalt chloride, at brief intervals has proved reliable as prophylactic measures; an intake of 8mg/week/sheep will be sufficient for prevention of deficiency symptoms.

The depletion of this element is a gradual process but when it is depleted, there is gradual decrease in appetite with consequent loss of weight, followed by muscular wasting, pica, anemia and death. This element is activating ion in certain enzyme reactions

Adult sheep needs about 0.1 mg cobalt daily. This requirement is higher in growing lambs (Lee, 1956, 1963, 1976; Marston, 1952; Smith and Gawlhom, 1975). Most of the foods contain traces of cobalt. Normal pastures have a cobalt content within a range of 0.1 - 0.25 mg/kg on dry matter basis. The body tissues poorly retain this element and excess is eliminated soon. The sheep are less susceptible to cobalt toxicity and have been shown to tolerate levels up to 3.5 mg/kg body weight.

Iodine: A deficiency of Iodine has been recorded in ewes leading to the birth of lambs with goiter. Indirectly, goiter may be caused due to eating goitrogenic substances containing feeds. Iodine deficiency in sheep during pregnancy can also lead to foetal hypothyroidism; therefore, it is necessary to feed iodised salt in certain areas to avoid iodine deficiency. Since this element is stored in thyroid glands, onetime dosing would be sufficient even at monthly intervals. A sheep needs 0.2 mg iodine daily (Mayo and Mulhearn, 1969; DeGroot and Stanbury, 1975; Willson, 1975).

The concentration of iodine present in the animal's body is very small and in the adult usually less than 0.6mg / kg. It is a constituent of thyroxine produced by thyroid gland. It is also a constituent of diiodotyrosine, which, is intermediate product in the formation of thyroxine from the amino acid, tyrosine.

It is found in traces in most of the feeds. Some seaweed may contain up to 0.6 per cent of iodine. Fishmeal is also a rich source of iodine. In goiter prone areas iodised salt can be given. It improves semen quality (Kaushish and Sahani, (1976).

Iron: It is an integral part of haemoglobin; hence its deficiency leads to subnormal haemoglobin levels. More than 90 per cent of the body iron is combined with protein. It is an integrated part of many enzymes. Thirty five per cent of the iron is present in haemosiderin. It also occurs in the form of transferrin in serum which is responsible for iron transfer from one part to another. About 20 per cent of body iron is present in liver, spleen and bone marrow.

It is present in various green leafy materials and seed coats. Some materials are good sources of iron, but the body cannot use these, e.g. blood meal. The absorption is largely controlled by body requirements. Excessive amounts of iron are prevented from entering the body by regulating mechanism mediated by the mucosal cells of intestinal tract. Iron deficiency is caused more due to the feeding of certain feeds, which are high in phytic acid.

Molybdenum: It is classified as an essential trace element. It is a component of Xanthine oxidase, which plays part in purine metabolism. Its deficiency symptoms have not been reported. A nutritious role of molybdenum has been demonstrated in young lambs. It promotes growth rate. The excess of this element in the body results in the deficiency (Marston, 1952; Alleroft, 1963).

Chromium: It plays role in lipid and protein synthesis and serum cholesterol. Its role has been established in sheep.

Zinc: High concentration has been found in wool. It is present in yeast, bran and germs of cereal grains. It is found in every tissue of animal body. This element accumulates in the bones. High concentrations have been found in the skin, hair and wool. It is a component of several enzymes such as carbonic anhydrase (respiratory enzyme), pancreatic carboxypeptidase and glutamic dehydrogenase. In addition to this, it acts as cofactor for many other enzymes. It is closely inter-related with calcium and vitamin-A. Parakartosis in lambs has also been found in zinc deficient diet, i.e. less than 30 ppm dietary zinc level. In rams zinc deficiency causes impaired testicular growth. Zinc toxicity causes anorexia. Lambs need fodder, which should contain 7-33 ppm of zinc to prevent disease (Smith and Gawthorn, 1975; Kaushish and Sahani 1976).

Manganese: It is present in very small amounts in the body. Its highest concentration is found in liver, kidneys, bones and pituitary gland and pancreas. It acts as enzyme activator. Forages deficient in manganese cause deficiency symptoms. Most of the pastures contain 20-40 mg/kg in dry matter. Rich sources are rice bran, wheat and offals.

Selenium: This element is interrelated with vitamin-E. The high doses lead to toxicity. In grazing animals, the distinct selenium responsive syndromes have been found, a muscular dystrophy, called white muscle disease, in newborn or young lambs also known as stiff lamb disease, unthriftiness with poor growth rates and infertility in ewes. Blind stagger is an acute form of selenium poisoning, which occurs in sheep after consumption of certain weeds such as *Astragalies bisuecatus,* which contains up to 0.4% selenium. In seleniferous plants, selenium replaces sulphur in amino acids methionine and cystine. Hair, wool and hooves, which are rich in sulphur containing amino acids, are affected adversely in selenium toxicity. It is known that the toxic effect of selenium is reduced when high protein foods are given to animals. Affected sheep may be given 1-5 mg sodium selenite at a few days interval (Godwin, 1975).

Vitamins requirements

Sheep require vitamin A, D and E. Since these vitamins are not likely to be lacking, deficiency symptoms are not often seen. However, in famine situation when the pasture does not provide sufficient green carotenoid material for longer period, the symptom of vitamin -A deficiency in the form of blindness is usually found. Pasture and ranges usually supply all the vitamin- A needed, as sheep have a great capacity for storing it in the liver. As the sheep are nearly always kept out of doors, sunshine provide the vitamin- D required, but it may have to be supplied to lambs being kept in sheds during winter. The ordinary rations fed to sheep contain ample vitamin- E, but lack of this vitamin in the diet of pregnant ewes may result in lamb disease. To reduce the incidence of this condition, oral dose of 5 mg selenium or one oral dose of 300 mg of alpha tocopherol is recommended. In general sheep do not require B- complex and C- vitamins. Healthy sheep synthesize the B- complex vitamins but the synthesis of cynocobalamin is very limited in sheep on cobalt deficient diet. It has been suggested that debilitated sheep with a high worm burden may benefit from the administration of B- vitamins.

Vitamins are organic substances, which are required by animal tissues in minute amounts. They are metabolically essential but sheep are able to synthesize certain vitamins in their tissues and they are able to utilize vitamins synthesized by micro- organisms in their gastro-intestinal tract. Vitamins are divided into two types, viz., water soluble and fat soluble. The fat-soluble vitamins are A, D, E and K.

Many of the symptoms of vitamin deficiencies are similar. These include anorexia, reduced growth, dermatitis, weakness and staggering

gait. In sheep vitamin A is more important and its deficiency can cause various kinds of blindness. Vitamin deficiency also leads to abnormal bone development, weak and stillborn lambs and respiratory problems. Vitamin D is essential for the growth and development of bones and metabolism of calcium and phosphorus, while vitamin E is concerned with reproduction.

Deficiency diseases of sheep

Deficiency diseases often denote conditions associated with faulty diets. Varying degrees of starvation result in multiple deficiencies and are manifested as generalized malnutrition. Specific, well-defined deficiency diseases of vitamins are not common in sheep. Mineral disorders are more common in several parts of the world. There is not much documentation from India.The overall macromineral status of Pakistani sheep is considered to be deficientKhan *et al.* (2007).

Chief deficiency diseases of livestock are of trace elements. Extensive established knowledge of these disorders has been recently reviewed (Underwood, 1977).

Protein: Protein deficiency is found in areas, where green fodder is scanty and poor quality roughages are fed. Its deficiency results in poor growth, depressed appetite, emaciation, delayed maturity and failure to come in estrous.

This deficiency can be corrected by giving green leguminous fodder, gram, guar, etc.

Vitamin A: Vitamin A deficiency occurs under drought conditions. Its deficiency results in karatinization of respiratory, elementary, reproductive, urinary and ocular epithelium. Deficiency results in lowering resistance to diseases. The lambs born are weak, malformed and dead. Severe deficiency results in night blindness, convultions, in coordination in gait, persistent diarrhea and anoestrous.

Lambs should be given colostrum at least for three days. They should be given cod liver oil and green fodder.

Vitamin B complex: The deficiency occurs in lambs deprived of green fodder, or good quality fodder. It is required by lambs up to 3 months of age. Thiamine, pyridoxine, pentothenic acid and riboflavin deficiencies do not occur in adult sheep but are essential for lambs with under developed rumen. Feeding green leafy feeds and fishmeal in their ration can relieve deficiency symptoms. They can be given orally or through intra muscular route.

Vitamin D: Deficiency occurs in lambs deprived of colostrum. Its deficiency results in rickets in lambs. Lambs are born weak and with congenital malformations. The lambs can be given injections and sun cured hay.

Vitamin E: The deficiency of vitamin E results in white muscle disease and muscular distrophy. 500 mg alpha tocopherol acetate given orally cures the lamb.

Calcium: Calcium deficiency in young lambs produces a disease known as Rickets. The joints become enlarged and bones of legs become bent. There is lameness and stiffness. Deficiency may result in osteomalacia in adults; the calcium removed from bones is not replaced. They become weak and fracture easily. A number of factors are responsible for calcium deficiency. Hypocalcaemia may be caused by parathyroid glands being unable to mobilize calcium to meet the high requirements of sheep, Hypocalcaemia may be one of the causes for non dilation of cervix in parturient ewes (Popoff, 1978). Feeding of concentrate has been reported to induce hypocalcaemia. Injections of calcium gluconate may restore calcium level. Annual application of lime to pasture land improves dental health (Suckling *et al.,* 1974).

Phosphorus: Like calcium, phosphorus is required for bone formation and its deficiency can cause osteomalacia or rickets. In chronic phosphorus deficiency the sheep may have stiff joints and muscular weakness. It may result in low fertility. Subnormal growth in young lambs and low body weights in adults are symptoms of phosphorus deficiency.

Intravenous infusion of phosphorus has been shown to be effective in improving the calcium and phosphorus balance of sheep (Towns *et al.,* 1978). The ration containing fishmeal, cereal grains may also relieve deficiency symptoms.

Sodium: Its deficiency retards growth and reduces the utilization of digested protein and energy.

Common Salt: A single experimental report from Rajasthan (Singh and Taneja, 1979) showed the adverse effects of high salt levels in water on lambing percentage, birth weight of lambs and parturition of ewes of Marwari breed. Surveys of the drinking water sources in the grazing areas of sheep and their effect on performance will be helpful.

Plants are low in sodium and chlorine. Deficiency results in anoxia and subsequent loss in weight. The addition of salt to the diet may provide an immediate cure.

Sulphur: Wool is rich in cystine and contains about 4 per cent of sulphur. Deficiency may result if sheep is given non proteinous nitrogen as a source of protein. Under these conditions addition of sulphur to urea containing rations may be beneficial.

Copper: Its deficiency may result in anemia, stunted growth, scours, bone disorders, depigmentation of wool, lesions in the brain stem and spinal cord and gastrointestinal disturbances. Muscular in coordination occurs in young lambs. Low copper content (2 to 4 mg/kg) in the dry matter may cause copper deficiency. Some genetic factors influence the concentration of copper in the blood, liver and brain of sheep and that the incidence of sway back can be affected by genotype. Number of crimps in wool is affected by copper deficiency.

Lewis *et al.* (1974) reported that the lesions of sway back developed after birth in lambs born to copper-deficient ewes. Parental administration of copper during gestation prevented the disease. Isolated myelin showed low copper content in deficient animals as compared to the controls (Patterson *et al.,* 1974). Liver copper levels were better indicators of copper status in ewes and lambs, in comparison to brain slices. A linear relationship was established between serum levels of copper and erythrocyte levels of superoxide dismutase in copper deficient rams (Andrewartha and Caple, 1980).

Several reports from different countries are available about copper toxicity in sheep on pasture and on copper toxicity produced experimentally (Bath, 1979; Dzhurov, 1979; Edelsten, 1980; Ontis *et al.,* 1980). Zinc had been shown to reduce the plasma copper concentration, but it had no effect on hepatic copper concentrations (Saylor and Leach, 1980).

Cobalt: Deficiency symptoms are likely to occur where, levels of cobalt in dry matter of pastures are below 0.1 mg/kg. The deficiency of cobalt is gradual and may result in muscular wasting, pica, severe anaemia and death.

Cobalt supplementation has proved to be effective in raising the blood level of vitamin B-12 and improves the blood picture of sheep (Tressoe and Lamond, 1979; Gyang and Sarror, 1979).

Fluorine: Fluorine is distributed in traces throughout the body, but is concentrated in the bones and teeth. The importance of flourine as a trace element in preventing dental caries has been well established. Physical differences were noted in the inner and outer parts of the tibial cortex of sheep, drinking water containing 100 ppm of fluoride. Fluoride might act as a possible mutagen in the ova of animals taking excess of it in feed or water. High fluoride content of water (7 mg/l) may not depress growth but it certainly causes fluorosis in animals

(Mandrik *et al.,* 1974). A report from Nairobi (Said *et al.,* 1977) suggested that the accepted safe level of fluorine in the form of NaFl (70-100ppm/l) was too high in the case of sheep. Tiwari *et al.* (1978) had discribed the pathology of chronic and acute fluoride poisoning in sheep. High accumulation of the element in the mandible of sheep (1240ppm) did not cause any depression in growth (Milhand and Cazieuz, 1980). Bone and joint abnormalities also occur. Fluorine is a cumulative poison and ingestion of small amounts over long periods of time may produce toxic symptoms. Incisors and molar teeth were affected by high, fluorine feed and water, plasma fluorine content was elevated, but the reproductive performance of adults and the growth of young ones were unaffected (Milhand *et al.,* 1980).

Iodine: Iodine deficiency in sheep manifests itself as a swelling of neck. Reproductive failure is one of the most outstanding consequences of reduced thyroid function; sheep gives birth to hairless, weak or dead lambs. Diseases caused by iodine deficiency in certain parts of the world, their pathogenesis, symptoms and treatments are well documented. A report from Australia (Andrewartha *et al.,*1980) suggests that the thyroxine concentration in the serum of new born lambs provides a more sensitive indication of hypothyrodism associated with iodine deficiency than the levels If the need for iron increases, as it would, after prolonged haemorrhage or during pregnancy, then haemoglobin synthesis may be affected and anaemia may result. Anaemia due to iron deficiency most commonly occurs in rapidly growing sucklings, since the iron content of milk is very low. The association of iron with heamoglobin is well established. Parentel administration of iron dextran certainly improves the blood picture of lambs but its effect on growth performance remains uncertain (Tait and Dubeski, 1979; Wanner and Bose, 1978).

Magnesium: Hypomagnesaemic tetany has been recognised since early thirties. It is also known as magnesium tetany, lactation tetany and grass tetany. Tetany is usually preceded by a fall in blood serum magnesium to about 0.5mg/100ml. By increasing the levels of sodium and potassium variability of magnesium is enchased the effect of the former is more than the latter (Powley *et al.,* 1977). Cold stress has been found to stimulate urinary excretion of magnesium and induce a drop in the levels of serum magnesium and phosphorus (Shiga *et al.,* 1979). Magnesium concentration of plasma has no relation with its absorption through the ruminal wall. The deficiency symptoms are, impaired growth, reproductive dysfunctioning, skeletal deformities and ataxia in newborn lambs. Injections of magnesium sulphate or magnesium lactate

subcutaneously can generally be expected to cure the animal if given early.

Selenium: Like molybdenum, selenium has always been regarded as an important element in animal nutrition because of its toxicity. Several out-breaks of selenium deficiency have been reported with paralysis, dullness, stiffness of joints, lameness and hoof deformities, reproductive failure and white muscle disease in lambs and ewes; they were cured by selenium supplementation (Sahebi, 1974; Whanger *et al.,* 1977b). The relationship between selenium status of the animal and its glutathione peroxidase activity in different tissues has been further substantiated (Dotta *et al.,* 1978, 1979; Paynter, 1979; Whanger *et al.,* 1977a). Sulphur intake has not been found to affect the selenium status of sheep (White and Somers, 1977). Selenium pellets containing 95 per cent iron, implanted in rumen can maintain the selenium status of sheep, but it is not a life long remedy. After three months of the treatment, there was a gradual decline in the availability of the element, (Paynter, 1979). Soft coal fly ash was shown to be a good source of selenium for sheep also (Hogue *et al.,* 1980). The corticosteriod concentration increased but the progesterone level was unaffected in selenium supplemented ewes during pregnancy (Walker *et al.,* 1979). Equivalent doses of sodium selenite and sodium selenate were equally effective. Parentel injections gave protection for a longer time as compared to oral dosing. The resistance of sheep erythrocytes to copper was not affected by the selenium status of the animal. The toxic effect of seleneum is reduced when high protein foods are given to animals. Trace amounts of arsenic compounds also have a protective action.

Zinc: A significant report of interest to Rajasthan is of Dwarkanath and Ghosal, (1981) who recorded subnormal levels of zinc in the serum of Nali sheep. Excess of zinc in the sheep rations had been responsible to induce severe copper deficiency, abortion, and stillbirth, reduced weight gains and feed intake. Copper supplementation did prevent copper deficiency symptoms, but failed to prevent the adverse effect of excess zinc. Lactating ewes have been shown to be prone to zinc deficiency, causing weight loss and deterioration in health, but the role of zinc during pregnancy was not understood (Apgar and Travis, 1979).

Nutrients for wool production

The wool production varies from breed to breed. It may be as low as 300 g in some Indian breeds and may be as high as 5 kg in some exotic breeds. If a sheep weighing 40 kg produces 3 kg of wool, 2.25kg is actual wool fiber and 0.75 kg is, suint and dirt. Budoriferous glands

produce suint, it is a mixture of potassium soaps, inorganic salts and potassium salts of lower fatty acids. Wool consists of esters of cholesterol, etc. Wool fiber is made up of protein and wool keratin.

Keratin contains sulphur containing amino acid, costive that in turn is synthesised from essential amino acid methionine. Keratin contains 10-12 percent of these amino acids. Maximum wool growth takes place at a level of nutrition only slightly above the maintenance level. At sub maintenance levels, when the sheep is losing weight, its wool continues to grow. The main factors determining the rate of growth of wool appears to be the quantity of protein digested and absorbed in the small intestine.

The highest rates of wool growth are achieved with foods, which promote high intakes of energy and protein. Wool quality is influenced by the nutrition of the sheep. High levels of nutrition increase fiber diameter and lower levels result in the production of fine wools. Finer wools are produced in areas in the ewes. Copper deficiency of fodder results in loss of crimps in wool.

Utilization of agro-industrial byproducts

Agro-industrial byproducts have become more important feedstuffs for ruminants with a competition for grains between men and animals. Over and above the conventional agro industrial byproducts, which are solely used in livestock feeding even the non-conventional agro-industrial byproducts are also used up to the level of 30-35% in ruminants diet (Jakhmola and Misra, 2000). The extensive use of non-conventional byproducts, may affect the nutritive value as well as production and health of the animals adversely if recommended levels are exceeded. Suitable treatments are to be given prior to their use in feed for efficient use. Large numbers of agro-industrial byproducts have been introduced in the feeding of Small Ruminants (Punj, 1995; Mathur, 1996 and Reddy *et al.,* 1996) in recent past. Use of Tumba *(Citrullus colocynthis)* seed cake, up to 33% level in concentrate ration did not have any ill effect on physiological status and health of Marwari kids Mathur *et al.* (2000).

Utilization of animal waste

A lot of recycling of animal organic waste, poultry waste and other slaughter as well as domestic wastes for the feeding of livestock has been taken up (Murthy *et al.,* 1995; Mathur, 1996; Brosh *et al.,* 1998; Khan *et al.,* 1998 and Choudhary, 2002). Animal wastes are generally high in fibre and NPN compounds and thus has potential for using in ruminants ration. The reutilization of such wastes in ruminants ration will not only

provide additional nutrient sources but will also help enterprises facing problem of waste disposal, due to limited resources, high disposal cost and above all increased awareness about environmental pollution (Jakhmola *et al.,* 1988).

Poultry droppings alone contribute 1.3 million tones of the dry matter excretion annually and contain up to 20% Crude Protein, out of which 2/3 rd is present in the form of NPN mainly uric acid which is efficiently utilized in the rumen, due to slow degradation. It can be used as protein supplement for ruminants if added along with rich source of readily available carbohydrates ensuring effective utilization of NPN by rumen microbes. No adverse effect on growth have been noticed when diet containing SDPD up to 20% was fed to Nali sheep (Mathur, 1996). The slaughterhouse waste like rumen contents is a potential source of nutrients for ruminants and can be recycled in animal feed after ensiling (Maynard *et al.,* 1980) to reduce cost of feeding and combat shortage of fed resources. Processing technologies like heating of poultry waste at 150°C for 20 minutes at thickness of 0-6 mm-deep stacking, ensiling are effective to kill the pathogens and improve utilization (Jakhmola *et al.,* 1988)

Nutrients for Reproduction

Dietary nutrition promotes the programming and expression of the metabolic pathways that enable animals to achieve their genetic potential for reproduction. Nutrition has an important impact on the reproductive performance in sheep, but the magnitude of the effect on reproduction may vary with the season (White *et al.,* 1983). Sheep are more prone to neglect compared to cattle and often suffer from lack of feed. This leads to decrease in body weight and loss of reproductive functions. It has been reported that the depleted body condition during period of energy deficiency also reduces heat tolerance (Naqvi, 1987, Hooda and Naqvi, 1990), which in turn affects the reproductive potential of sheep. Concurrently, Rhind and Mc Neilly (1986) showed that ewes with low body fat reserves had fewer large ovarian follicles and therefore the potential for subsequent maturation and ovulation declined. The reproductive efficiency of most of breeds of sheep of India is relatively low (Arora and Garg, 1998). The nature of nutritional resources and management problems differs with climate, soil and vegetation, the physical process, which governs the animal's reproductive performance.

Effect of Nutrition in Pregnancy

Under-nutrition during fetal life reduces subsequent litter size (Robinson, 1990'). Under-nutrition effects on the concentration of

oogonia in the ovary as early as day 47 of fetal life (Borwick *et al.,* 1994; Naqvi *et al.,* 1996). High plane of nutrition during the post mating period can, adversely affect the embryo survival (McKelvey *et al.,* 1988).

Effect of nutrition on puberty

Puberty occurs approximately at 7 to 9 month of age. Its onset is influenced by breed and strain differences, the nutrition plane and time of birth, critical body size Restricted nutrition during the early life results in delay in onset of puberty (Dyrmundsson, 1987; Foster *et al.,* 1988). Adequate nutrition is necessary for the proper pubertal development. High plane of nutrition advances the puberty considerably. There is good evidence that inadequate nutrition can have adverse effect on the pituitary function and level of nutrition may influence the response of target organs to either gonadotrophin or gonadal hormone (Lamming, 1969). The dietary energy level affects the blood profile of ewes (Naqvi and Rai, 1988; Maurya *et al.*, 1998), which indirectly affects the reproductive potential of ewes. Low feed intake delays puberty.

Effects of nutrition on estrus and ovulation rate

Under nutrition affects the incidences of estrus markedly (Maurya *et al.,* 2004) and some times estrus is completely inhibited (Hafez, 1952). It is well established that the follicular development in the many mammals is affected by nutrition

Ovulation rate is one of the most important determinants of reproductive performance in sheep, which depends on the age (Knight *et al.,* 1975), genotype (Wheeler and Land, 1977) and stage of breeding season (Devis *et al.,* 1976; Maurya *et al.,* 1998) as well as nutrition (Gunn, 1983). The lower ovulation and lambing rate in ewes maintained under condition of minimal management can be increased by providing them good nutrition (Gunn, 1983; Naqvi *et al.,* 2002). Heavier ewes with in the flock, have more ovulations than the lighter ones, showing about 2.5-3.0% increase for each 1.0 kg increase in live weight (Cumming (1977). The net nutritiónal status of ewes also affects the ovulation rate. Lindsay (1976) suggested that ovulation rate in ewes depends on the net nutritional status of the ewes.

Effect on embryo mortality

High intake of rumen degradable protein, leads to excess rumen ammonia production, which is associated with reduced pH of the uterine environment which in turn leads to the embryonic death (Elord and Butler, 1993). Progesterone plays a crucial role in maintaining

pregnancy in ewe (Denamur and Martinet, 1955). Parr *et al.* (1987) demonstrated that sheep fed high-energy ration after mating had reduced progesterone levels and showed an increase in embryo mortality. Dietary induced suppression of circulating progesterone during oocyte maturation in severe under-nutrition significantly decreases the pregnancy rate of sheep (Abecia *et al.,* 1994, Maurya *et al.,* 2004).

Effect on fetal and neonatal metabolism

Nutrition can have the greatest effect on total potential lamb production during this period. Under-nutrition decrease uterine blood flow and accompanying decrease in fetal insulin and IGF-I and impair fetal growth and development (Table 15.6). Fetal urea concentration increase during the under-nutrition, reflecting increase in gluconeogenesis by fetus from amino acids (Bell, 1993). Under nutrition during pregnancy significantly reduces the live birth weight of lambs (Maurya *et al.,* 2004).

Nutritional considerations for augmentation of reproductive performance focus attention on meeting the nutrient requirements of lambs for achieving early puberty for proper spermatogenesis, semen quality and libido of rams and also of pregnant and lactating ewes for prenatal and postnatal development of the lamb. The effect of nutrition on the reproductive process is mediated through hormones specific for sexual development and for different phases of reproduction. High plane feeding may advance puberty considerably in small ruminants but over fattiness has an adverse effect on the reproductive performance of both males and females. Early nutrition of the lambs needs to be regulated depending upon whether the young one is to be reared for meat production or fibre production (Table 15.7). Under nutrition or malnutrition of the male lamb delays sexual maturity and affect androgenic activity, spermatogenesis as well as reduced viability and motility of the spermatozoa. Additional supplementation of energy to ewes maintained on low plane of nutrition increases tupping rate, while dietary nutrients as protein, phosphorus and vitamin-A enhance ovulation and conception rates. Pregnant and growing ewes should be provided nutritional allowances both for growth and gestation. Meeting nutrient demand during last 6 weeks of gestation is of critical importance for the growth and development of the foetus as well as the lambs. Under nutrition may result in depression in the activity of the hypothalamic pituitary axis accompanied by decrease in the release of various hormones responsible for reproductive performance (Table 15.8).

Table 15.6. Faecal output, nutrient digestibility and intake of nutrients in Marwari ewes grazing on natural rangeland in arid region

Attributes	Season I	Season II	Season III	Season IV
	(Jan-Mar.)	(April-June)	(July-Sept.)	(Oct.-Dec)
Average body weight of ewes (kg)	28.2	26.5	28.6	31.8
Faecal out put (g/ day)	508.15	468.97	617.74	715.87
Digestibility coefficient (%)				
Dry matter	44.26	40.55	37.80	28.38
Crude protein	14.47	16.36	16.88	17.28
Crude fiber	61.47	58.63	64.14	37.93
Nitrogen free extract	53.34	48.15	54.36	41.89
Intake of nutrients (g/day)				
Dry matter	906.12	792.44	987.35	1013.67
Crude protein	53.01	49.22	93.51	73.19
Crude fiber	297.31	261.35	260.75	*304.01*
Ether extract	6.53	2.22	9.58	15.21
Nitrogen free extract	472.00	422.39	454.52	491.85
Ash	77.30	57.62	140.01	129.45
TDN	442.08	364.50	445.44	333.98
DCP	7.57	8.05	15.78	12.65
DM intake/100kg wt	3.21	2.99	3.45	3.19

Under feeding in late pregnancy may lead to abortion, mortality and loss of milk in ewes. Ewes require DM containing 12 per cent CP and 52 per cent TDN @ 4 kg/100 kg body weight during advanced stage of pregnancy. Ewes require DM @ 100 g/kg $W^{0.75}$ containing 12 per cent CP and 55-58 per cent TDN during lactating phase. The lactating ewes require 255 Kcal ME and 7.85 g DCP /kg $W^{0.75}$. It is suggested to supplement high quality dry roughages or concentrate mixture to the grazing sheep to meet their nutritional requirements during advanced stage of pregnancy and early lactation.

Feed Additives

Feed additives are compounds, which stimulate growth, improve efficiency of feed utilization and may be beneficial to the health of the animal. Antibiotics, sulpha drugs, hormones, buffers, activated carbons, antioxidants, bentonites and bloat controlling compounds are in use as feed additives.

Table 15.7. Requirements of digestible nutrients and minerals of lambs raised for mutton

Body Weight (kg)	Daily Weight gain (kg)	Daily					Percentage				
		Intake per lamb	T.D.N.	M.E. Mcal/kg	Protein	D.C.P.	Calcium	Phos-phorus	Salt	Vit. m.g	Vit. m.g.
27.2	0.16	1.22	55	2.42	12.0	6.6	0.23	0.21	0.6	450	121
31.8	0.18	1.41	58	2.56	11.0	6.1	0.21	0.18	0.6	470	126
36.3	0.20	1.54	62	2.72	10.7	5.9	0.19	0.18	0.6	498	132
40.8	0.20	1.68	62	2.70	9.5	5.3	0.18	0.16	0.6	507	134
45.4	0.18	1.77	62	2.73	9.4	5.2	0.18	0.16	0.6	529	146

Source: NRC feeding standards 1966

Table 15.8. Nutritional requirements of sheep on dry matter basis

Body weight (kg)	Daily weight gain (kg)	Daily intake per animal (kg)	Percentage								
			T.D.N	M.E	Protein	D.C.P.	Calcium	Phosphorus	Salt	Vit. m.g	Vit.D i.u.
DRY AND FIRST 15 WEEKS OF GESTATION											
45.4	0.03	1.18	50	2.2	8.0	4.4	0.27	0.21	0.8	238	212
54.4	0.03	1.36	50	2.2	8.0	4.4	0.24	0.19	0.7	242	220
63.5	0.03	1.54	50	2.2	8.0	4.4	0.22	0.17	0.7	256	227
72.5	0.03	1.72	50	2.2	8.0	4.4	0.20	0.16	0.7	258	231
LAST 6 WEEKS OF GESTATION											
45.4	0.17	1.72	52	2.29	8.4	4.6	0.24	..a. 18	0.6	403	146
54.4	0.17	1.90	52	2.29	8.2	4.5	0.23	0.17	0.6	428	156
63.5	0.17	2.09	52	2.29	8.0	4.4	0.22	0.16	0.6	454	168

Table Contd.

Table Concluded

Body weight (kg)	Daily weight gain (kg)	Daily intake per animal (kg)	Percentage								
			T.D.N	M.E	Protein	D.C.P.	Calcium	Phosphorus	Salt	Vit. m.g	Vit.D i.u.
72.6	0.17	2.18	52	2.29	7.8	4.3	0.22	0.16	0.6	503	183
			8 TO 10 WEEKS AFTER PARTURITION								
45.4	0.04	2.09	59	2.60	8.7	4.8	0.30	0.22	0.5	333	119
54.4	0.04	2.27	58	2.56	8.4	4.6	0.28	0.21	0.5	359	132
63.5	0.04	2.49	56	2.47	8.0	4.4	0.27	0.20	0.5	379	141
72.6	0.04	2.58	55	2.42	8.0	4.4	0.27	0.20	0.5	423	154
1	2	3	4	5	6	7	8	9	10	11	12
			FEMALE LAMBS								
27.2	0.14	1.22	55	2.42	11.0	6.0	0.21	0.19	0.6	187	110
36.3	0.09	1.45	50	2.20	8.7	4.8	0.20	0.18	0.6	214	137
45.4	0.06	1.54	50	2.20	7.6	4.2	0.20	0.18	0.6	243	163
54.4	0.03	1.54	50	2.20	7.0	3.9	0.20	0.18	0.7	298	194
			MALE LAMBS								
36.3	0.18	1.45	62	2.73	10.0	5.5	0.20	0.18	0.6	214	137
45.4	0.14	1.68	57	2.51	8.6	4.7	0.18	0.16	0.6	225	150
54.4	0.09	1.90	50	2.29	7.6	4.2	0.17	0.15	0.6	240	156
63.5	0.05	2.09	50	2.29	6.9	3.8	0.16	0.14	0.5	258	168

Antibiotics

Chlortetracycline, oxytetracycline and bacitracine affect various enzyme systems such as oxidative phosphorylation reactions. Lambs fed a milk replacer, which had a supplement of antibiotic, vitamins and iron added to a basal replacer had a slight response. Antibiotics given to lambs in creep ration may improve weight gain and feed conversion. Cholortetracycline, oxytetracycline and oleandomycine may be beneficial in terms of greater weight gain and improved feed conversion. Feeding of antibiotics reduces incidences of diarrhoea, off feed and enterotoxaemia. Feeding of antibiotics reduces the incidences of urinary calculi formation.

Activated charcoal

Five percent activated carbon had no effect on weight gain or feed efficiency of lambs fed a ration based on apple pomac contaminated with D.D.T. Feeding of activated charcoal has been found to be effective in reducing tissue contamination of ronnel when the pesticide and carbon were fed together.

Bentonite

Sodium bentonite is used as a pellet binder. Two per cent level of bentonite produces an apparent improvement in nitrogen retention, weight gain and feed consumption in lambs fed high roughage rations but if the concentration of bentonite is increased to 4 or 8% it reduced phosphorus retention.

Bloat controlling compounds

Surface acting agents are effective in controlling pasture bloat if a regular intake is ensured. Poloxalene prevents pasture bloat when given as a top dressing on supplementary concentrate. Poloxalene in grain or molasses salt blocks reduces the severity of bloat in lambs. Pluronic L62, a polyoxypropylene polymetcontrols bloat when given in water.

Buffers

Carbonates, bicarbonates, hydroxides, oxides and salts like sodium sulphite and ammonium chloride are being used on buffers. Feeding of these compounds change the pH of the ruminal contents. In case of feeding of high concentrate rations, the need for feeding of these compounds occurs, because of less chewing and regurgitation, which in turn results in less salivation and a reduced amount of bicarbonate coming in the, rumen. Including 3% buffers (2:1 maganesium and potassium bicarbonates) resulted in weight gain in lambs even though roughage was reduced suddenly from 60 to 10%.

Feeding of sodium and potassium bicarbonate throughout finishing period in lambs improved gains, whereas, feeding of hydroxides of aluminium, calcium and magnesium have no effect. Sodium bicarbonate feeding may or may not improve lamb performance.

Hormones

During the past few decades, growth hormones, natural and synthetic adrenal cortical hormones, natural and synthetic estrogens, androgens, natural and synthetic progestogens, androgen estrogen combinations, thyroid and antithyroid compounds have been used for fattening the lambs

Thyroid active hormones

Studies with lambs have not indicated favourable responses when they were fed methimazole, a growth active hormone. There is very little current interest in feedlot use of growth active compounds.

Growth stimulating hormones

Diethylstilbestrol and hexosteral (estrogen); melengestrol acetate (progesterone); have been fed orally or have been used as implant for feed lot lambs. The response had been poor with growth hormone and cortisone. Estrogens and progestogens cause increased retention of nitrogen, which results in better feed efficiency and growth. Recent researches have indicated that subcutaneous implants (15-30mg) will produce the same responses as feeding 10-20 mg/day. Common levels for lambs are implants of 2-3 mg. These hormones are effective in young lambs.

Diethystilbestrol and other hormones give better response when the quality of the ration is relatively high, produce better response than those that are inadequate. Use of melengestrol acetate, a synthetic progestogen did not indicate much promise for feedlot experiments in lambs.

Methane inhibitors

Researches with some methane inhibitors such as dichlorovinyl dimethyl phosphate, sodium sulphate, hemiacetal derivatives of chloral and starch and a vide variety of halogenated analogues of methane such as chloroform, carbon tetrachloride, methylene chloride and bromochloromethane have been carried out.

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16.

Pastures and Forages

The average cultivated area devoted for fodder production is only 4.4 per cent pasture and cultivable wastelands are approximately 13 and 15 million hectares, respectively. The total area under forests is 25 million hectares and that open to grazing is 21 million hectares. These resources are able to meet the fodder requirements of grazing animals only during the monsoon season. Sheep is the only animal, which can utilize such pastures efficiently. Cross breeding of native sheep is being adopted for improving productivity in most of the states. The nutrient requirements of crossbreds are more because of higher production.

Only 2-3 sheep per hectare can survive on our pastures. The livestock population is increasing at alarming rate and the area of pastures is also decreasing. Under these circumstances the only alternative left is increasing production from our pasturelands. This is possible by better management of rangelands and by growing good quality fodders. *Cenchrus* and *Lasiurus* species perform well under arid conditions. Crude protein and Total digestible nutrient contents of these grasses are 5.26 and 43.48 and 3.02 and 41.38 per cent, respectively. Hundred young sheep need about 300 quintal fodder in a year, which can be obtained from 10 hectare of land by better management.

General Tree Plantation

There occurs shortage of fodder for sheep from March to June in arid and semi arid areas. The lopping of fodder trees is a common practice in most parts of this country especially in the hills, for feeding sheep, as well as goats and cattle. The growing of fodder trees should constitute an important programme in developing fodder resources for sheep. The availability of fodder trees is particularly useful during scarcity periods. This shortage can be met by planting fodder trees and the sheep will get nutritious fodder during lean period. Sheep relish leaves of *subabool (Leucaena leucocephaIa), ardu (Ailanthus excelsa), khejri (Prosopis cineraria), babool (Acacia arabica), kachnar (Bauhinia variegata),* etc. These trees can be lopped in November/December and April/May.

The dried preserved leaves of these trees can also be fed during lean periods. One hundred trees should be planted in a hectare of land. Plant to plant distance may be 10 meter. A 0.5 × O.5 × O.5 m pit is dug for planting a tree sapling. Ten kilogram organic manure and well rotten tree leaves are put in each pit. BHC is also mixed with soil, before planting a sapling. It is watered immediately; thereafter the plant should be watered every fortnight.

These trees are not lopped up to 3 years. The branches more than 1 inch in diameter should not be cut; otherwise, the tree may die. The mature trees can yield up to 8-10 quintals of green fodder per hectare. In addition to it, we get timber for household consumption also. The chemical composition of some of the fodder tree leaves is given in Table 16.1. The details of some fodder trees are given below.

Ailanthus excelsa

Vernacular names: *Ardu*, *Maharukh*, *Mahanim*, *Pinari*, *Ped damanu*

Distribution: It grows in Gujarat, Rajasthan, Haryana, Punjab, Uttar Pradesh, Bihar, Odisha and the Deccan plateau (Troup, 1921).

Habitat: It grows well in semi arid and semi-moist regions (Seth *et al.,* 1962). It grows in dry areas where the annual rainfall is 400 mm (Bhimaya *et al.,* 1963). It grows on a wide variety of soils, but thrives best on porous sandy loams (Chaturvedi, 1956a). Leaf shedding takes place in February and new leaves appear in March-April.

Planting: The seed is sown in well prepared nursery beds. The sowing is done in lines 20 cm apart. About 15 g seed is sufficient for sowing each square meter of nursery area. Germination commences in about 10-15 days and is completed in about 45 days. Planting is done during monsoon rains. Plants are uprooted in the morning with balls of earth and are planted the same day, on the bunds of the fields and pasture plots in pits of the size of 0.5 m^3 dug one month in advance. The watering is done once in a month during summer in first year and once in 2 months in second year.

Nutrients: Its leaves are highly palatable and nutritious. An average tree yields about 5-7 quintals of green leaves twice a year (Bhandari and Gupta, 1972). The leaves of this plant are rich in crude protein, ether extract and calcium, but poor in phosphorus when dry. The digestibility coefficients are fairly high for the nutrients. The crude protein digestibility from green leaves is fairly high and nearly equals berseem, while nitrogen free extract digestibility compares well with mulberry leaves and berseem. Green leaves can serve as a maintenance ration for

livestock. Dry or green leaves can be mixed with dry fodder as protein supplement. Its dry leaves contain 19.9 per cent crude protein (CP), 12.8 per cent crude fiber (CF), 5.5 per cent ether extract (EE) and 51.8 per cent nitrogen free extract (NFE). A young sheep can consume green and dry leaves @ 3.5 to 4.0 and 2.3 per cent, respectively, of its body weight. Young sheep can drive 130 g digestible protein and 510 g total digestible nutrients from its leaves.

Albizia lebbek

Vernacular names: *Siris*, *Nirith*, *Chichola*, *Sirin*, *Vagai*, *Dirsinam*.

Distribution: It grows wild in Andaman Islands, Chhota Nagpur, Kerala, Rajasthan, Tamil Nadu and West Bengal (Troup, 1921) and in sub Himalayas up to an elevation of about 1500 m (Venkataramany, 1968).

Habitat: In its natural habitat, the maximum shade temperature reaches about 48°C and minimum temperature varies from about 2 to 8°C. The annual rainfall varies from about 600 to 2500 mm. It is suitable species for planting in dry areas of Rajasthan with annual rainfall of less than 300 mm (Bhimaya *et al.,* 1963).

Planting: It grows well on black cotton soil (Troup, 1921) and deep loam soil. It can tolerate salts in soil (Hussain, 1977). Seedlings attain a height of about I-2m during first year and 3-4 m in second year in irrigated nurseries. The tree is moderate in height. It can be raised either by direct sowing or planting of nursery raised seedlings. The latter gives better results (Muthana *et al.,* 1976). Stump planting, gives better success and is the easiest method for raising this species (Kadambi and Dabral, 1955; Mathauda, 1956; Venkataramany, 1968). The seed sowing is done in lines, which are 3 m apart. About 20 kg seed is sufficient to sow one hectare.

Seedlings can also be raised by sowing the seeds either in nursery beds or in containers in March-April. Germination commences in about a week and takes about a month to complete (Seth *et al.,* 1962). Planting is done in July in 30 cubic centimeter pits. Entire plants are uprooted from the nursery with balls of earth.

Nutrients: Its leaves are reported to be good fodder. The leaves contain 0.23 per cent tannins (Lohan *et al.,* 1979). The average digestibility coefficient for CP, EE, CF and NFE are reported to be 67.9,56.1,41 and 48, respectively, and total digestible nutrients per quintal of leaves on dry weight basis are 11.6 kg crude protein, 37.2 kg of carbohydrate and 0.36 kg of ether extract (Sen and Ray, 1971).

Table 16.1. Fodder crop calander

Name of crop	Varieties	Time of sowing	Seed rate. (kg/ha)	Manuring (kg/ha)	No. of irrigation	No. of cuts	Fodder yield (tonnes/ha)
Cowpea	H.F.G. 41 1 F.O.S. 1 UPC 42, Chorodi	March to July	40-50	N $_{25}$, P_2O_5 62.5, K_2O_5 100	3-4	2	30–35
Guar	FS 227 H.F.G. 119, 156 Bundle Gaur 1-2	April to mid July	40-50	N 20, P_2O_5 50	3-4	1	25-30
Bajra	Raj Bajra Chari 2	March to August	8-10	N 75	2-3	2-3	40
Berseem	Mascavi BL 2	October	20-25	N 25, P_2O_5 70, K_2O 60	5-6	5-6	70-80
Jowar	JS 20, JS 263 CVS 15 CSH 13, MP Chari Pusa Chari	March to July	50-60	N 50, P_2O_5 15,	2	1 3-4 (Multicut)	40-50
Lucerne	Anand 2,3 Sirsa 8,9	October to November	12-15	N 20, K_2O 30, P_2O_5 60	5-5	8-10	70-75
Maize	African Tall Co 1	April to August		N 50 K_2O 20, P_2O_5 30	5-6	1	35-40
Mustard		September	6-8	N 30	2	1	30-35
Napier Hybrid		March to August	33,000 root slips	N 35, K_2O 15, P_2O_5 25	Fortnightly	6-8	110-130
Oats	JHO 822 Weston 110, Kent	October to November	75-100	N 60, P_2O_5 15, P_2O_5 30	3-4	2-3	30-40

Table 16.2. Chemical composition of some fodder trees and shrubs

Botanical name	C.P. %	C.F. %	N.P.E. %	E.E. %	Ash%	References
Acacia aneura	12.8	32.9	47.2	1.1	6.0	Everist *et al.,* 1958
Acacia brachystachya	10.4	41.9	38.2	5.7	4.1	Everist, 1969
Acacia brevispica	18.8	18.0	51.0	5.7	6.5	Dougal and Bogdan, 1958
Acacia cambagei	13.3	15.9	55.2	3.1	11.0	Everlst, 1969
Acacia casia	11.3	30.2	48.6	3.2	6.0	Everlst, 1969
Acacia catechu	13.0-18.8	21.9-22.6	46.7-51.0	3.05-4.6	9.7-9.8	Sen and Ray, 1971; Pal *et al.,* 1979
Acacia catenulata	13.9	21.9	58.4	2.9	2.9	Everlst, 1969
Acacia deanei	14.3	18.9	55.6	4.8	3.4	Everist, 1969
Acacia excelsa	11.8	21.4	56.7	3.6	6.5	Everist, 1969
Acacia farnesiana	18.4	18.5	56.5	2.0	4.4	Everlst, 1969
Acacia gerrardii	17.7	24.2	50.5	1.6	6.0	Dougal and Bodgan, 1958
Acacia girciffae	12.6	34.2	47.9	1.8	3.6	West, 1950
Acacia narpophyUa	26.7	19.3	45.7	1.1	7.2	Everist, 1969
Acacia mellifera	42.9	16.2	32.2	2.6	6.2	Dougal and Bodgan, 1958
Acacia nilotica	13.9	9.2	69.8	-	7.1	Ganguli *et al.,* 1964
Acacia nubica	32.5	15.8	41.2	1.7	8.9	Dougal and Bodgan, 1958
Acacia pendula	13.2	29.6	46.2	3.4	7.8	Everist, 1969
Acacia sparsiflora	17.8	25.4	47.7	3.3	5..8	Everist,1969
Adina cordifolia	8.7-12.5	12.1-13.8	-	3.1-5.6	7.7-8.2	Majumdar *et al.,* 1967 a

Table Contd.

Table 16.2. *Contd.*

Botanical name	C.P. %	C.F. %	N.P.E. %	E.E. %	Ash%	References
Aegle marmelos	15.1-15.3	16.5-18.1	48.4-52.8	1.4-1.5	14.0-16.8	Sen and Ray, 1971
Ailanthus excelsa	19.6	13.5	47.7	3.7	15.5	Singh and Patnayak, 1977a
Albizia amara	26.8	26.8	38.4	1.9	6.1	Dougal and Bogdan, 1958
Albizia basaitica	12.8	21.5	56.5	4.5	4.5	Everist, 1969
Albizia chinensis	15.1	31.6'	43.6	4.4	-	Sharma *et al.,* 1969
Albizia lebbek	16.8-26.5	26.5-37.5	36.09-42.8	2.8-4.7	7.1-11.5	Sen and Ray, 1971; Sharma *et al.,* 1966a; Pal *et al.,* 1979
Anogeissus latifolia	7.5-11.5	16.4-24.1	55.4	2.7-4.4	8.7-10.9	Majumdar *et al.,* 1967 a.b; Sen Ray, 1971
Anogeissus pendula	7.6	19.0	65.3	-	8.1	Ganguli *et al.,* 1964
Artocarpus heterophyllus	11.2-14.2	18.7-22.8	46.3—5.7	2.3—3.5	8.3—14.2	Sen and Ray, 1971
Azardirachta indica	12.4-18.3	11.4-23.1	42.3—66.6	2.3—6.2	7.7-18.8	Patel and Patel, 1957, 1962; Ganguli *et al.,* 1964; Sen and Ray, 1971
Baphia nitida	21.2	26.8	-	-	5.4	Rose Innes and Mabey, 1964
Bauhinia carronii	13.7	13.5	64.8	1.6,	6.3	Everist, 1969
Bauhinia hookeri	11.8	13.5	64.3	2.3	8.1	Everist, 1969
Bauhinia variegata	10.7-15.9	25.3-33.0	40.9-51.8	1.3	1.37-12.3	Sharma *et al.,* 1966a, 1968, Majumdar *et al.,* 1967a
Butea monosperma	11.5	-	-	-	9.3	Gupta *et al.,* 1975
Cajanus cajan	16.9	29.2	36.8	9.9	7.1	Otero, 1952
Careya arborea	10.4	25.9	42.6	7.7	7.5	Sen and Ray, 1971
Celtis australis	14.5-15.3	19.5-21.5	42.7 - 49.0	2.5-5.6	11.6 -17.8	Sharma *et al.,* 1966b; Pal *et al.,* 1979

Table Contd.

Table 16.2. *Contd.*

Botanical name	C.P. %	C.F. %	N.P.E. %	E.E. %	Ash%	References
Cordia dichotoma	12.4-15.1	16.5 - 26.8	41.9-52.8	1.5-2.9	12.6-17.1	Sharma *et al.,* 1966a; Sen and Ray, 1971; Pal *et al.,* 1979
Dalbergia sissoo	16.7	22.2	49.4	3.2	8.6	Momin and Ray, 1943
Desmanthus virgatus	22.4	-	-	-	-	Takahashi and Repperton, 1949
Desmodium discolor	18.5	25.8	39.1	1.8	1.5	Otero, 1952
Desmodium molle	16.9	23.6	46.1	404	9.1	Otero, 1952
Desmodium pabulare	20.2	22.6	41.6	5.8	9.8	Otero, 1952
Dichrostachys cinerea	15.3	28.1	50.5	1.2	4.9	Wilson and Bredon, 1963
Diospyros melanoxylon	7.1	25.3	56.0	2.2	904	Sen and Ray, 1971
Ehretia laevis	13.5	18.0	51.2	*6.0*	11.4	Sen and Ray, 1971
Eriosema englerasium	18.5	-	-	-	-	Lawton, 1968
Ficus *bengalensis*	7.7-11.2	13.9-30.0	37.6-51.6	2.5-5.1	9.3-16.9	Patel and Patel, 1957; Mia *et al.,* 1960; Pal, *et al.,* 1979
Ficus glomerata	11.2-15.2	12.3-16.5	56.5-59.0	2.2-2.9	11.9-18.4	Majumdar and Momin. 1960; Majumder, *et al.,* 1967a
Ficus lacor	8.5-15.7	12.8-25.8	44.8-61.1	1.8-3.4		Momin and Ray 1943; *Majumdar et al.,* 1967b
Ficus religiosa	15.6	26.9	39.0	3.8	14.5	Singh and Patnayak, 1977a
Ficus roxburghii	12.3-13.4	7.7-17.8	50.0-64.9	4.5-4.7	9.4-15.4	Joshi and Ludri, 1966 Sharma *et al.,* 1966a
Griffonia simplicifolia	15.7	-	-	29.3	8.5	Rose Innes and Mabey, 1964
Grewia optiva	15.6	20.9	47.0	6.7	9.8	Johri and Talpatra, 1971
Hardwickia binata	9.0	-	49.7	4.0	-	Prasad *et al.,* 1974
Holoptaleal integrifolia	13.7	-	-	1.9	14.5	Sen and Ray, 1971

Table Contd.

Table 16.2. *Contd.*

Botanical name	C.P. %	C.F. %	N.P.E. %	E.E. %	Ash%	References
Kydia calycina	11.1-13.6	14.5-23.7	46.1	3.3-6.1	15.3-19.8	Majumdar *et al.,* 1967a; Sen and Ray, 1971
Lagerstoraemia parviflora	7.8	17.3	58.2	5.7	11.1	Sen and Ray, 1971
Lannea coromandelica	11.4-16.2	16.1-19.8	53.1-59.1	2.5-4.2	8.5-9.2	Sen and Ray, 1971
Leucaena leucocephala	24.2	13.3	-	4.4	10.8	International Consultation on Ipil Res. 1976.
Madhuca longifolia	9.1-9.8	18.7-20.3	59.4-60.7	3.8-4.1	6.7-7.8	Sen and Ray, 1971
Mallotus philippinensis	13.4	29.7	44.6	3.7	8.7	Sen and Ray, 1971
Melia azedirach	-	13.3	-	-	-	Gupta, *et al.,* 1975
Milletlia thonnini	19.0	29.5	-	-	8.8	Rose Innes and Mabey, 1964
Mitragyno parvifolia	7.7	19.6	60.7	-	8.7	Sen and Ray, 1971
Moringa oleifera	15.3-20.7	7.1-17.9	48.7	4.4-11.1	11.8-14.2	Majumdar *et al.,* 1967a,; Sen and Ray, 1971
Morns alba	15.0-27.6	9.1-15.3	40.1-49.1	2.3-8.0	14.3-22.9	Jayal and Kehar, 1962; Majumdar *et al.,* 1967a; Narayan and Setty, 1977; Pal, *et al.,* 1979
Ougeinia oojeinensis	11.6-15.1	21.9-26.5	47.6	1.4-4.3	10.0-14.9	Majumdar *et al.,* 1967a; Sen and Ray, 1971
Parkinsonia ciculeata	13.1	24.9	47.9	1.9	11.9	Everist,1969
Piliostigma thonningii	9.9	22.1	59.1	1.9	7.1	vanRensburg, 1968
Pongamia Pinnata	17.6	-	-	-	-	Gupta *et al.,* 1975
Prosopis cineraria	13.9	20.3	59.2	-	6.5	Ganguli *et al.,* 1964
Quercus dilatata	9.6	29.1	51.8	4.5	5.1	Sen and Ray, 1971
Quercus glauca	9.6	29.0	49.6	4.1	7.6	Sen and Ray, 1976

Table Contd.

Table 16.2. *Concluded*

Botanical name	C.P. %	C.F. %	N.P.E. %	E.E. %	Ash%	References
Quercus leucotrichophora	10.2-11.4	31.3-32.1	46.7-48.4	3.5-4.8	5.1-6.4	Sharma *et al.,*1966a; Sen and Ray, 1971
Robinia pseudoacacia	25.5	17.2	46.5	3.3	7.5	Singh *et al.,* 1959
Schleichera oleosa	10.4	32.3	49.2	1.9	6.1	Sen and Ray, 1971
Shorea robusta	10.1	27.4	55.7	3.2	3.9	Sen and Ray, 1971
Syzygium cumini	7.9	20.7	61.7	2.6	7.0	Momin and Ray, 1943
Tamarindus indica	13.4-14.4	15.9-20.2	46.0-60.5	1.9-7.0	7.9-10.4	Patel and Patel, 1957; Sen and Ray, 1971
Terminalia alata	8.3-12.7	13.1-21.8	54.1	1.4-4.9	9.1-12.1	Majumdar *et al.,* 1967a; Sen and Ray, 1971
Terminalia belerica	8.6-14.0	16.7-18.6	54.5-60.1	3.1-4.7	7.6-11.7	Sharma *et al.,* 1966a; Senand Ray; 1971; Pal *et al.,*1979
Ziziphus mauratiana	15.4	15.8	-	-	6.7	Kohli *et al.,* 1969

Azadirachta indica

Vernacular names : *Neem*, *Nim*, *Limba*, *Bavina*, *Veppu*, *Vepa*, *Veppam*

Distribution: It grows in Andhra Pradesh, Bihar, Gujarat Haryana, Karnataka, Maharashtra, Madhya Pradesh, Odisha, Punjab, Rajasthan, and Uttar Pradesh. It grows wild in Irawadi valley (Brandis, 1906).

Habitat: The temperature ranges between 2 and 40°C in the areas where it grows. It is suscepsible to frost. It is commonly found where the annual rainfall varies from 250 to 1150 mm. It grows well on a wide variety of soils ranging from sandy in Rajasthan to clayey in Maharashtra. It can persist under adverse soil conditions also, where very few tree species can grow (Chaturvedi, 1956 b).

Planting: The seeds germinate quickly and attain a height of 20 to 30 cm by the end of the first season. While a limited supply of soil moisture restricts plant growth, excessive soil moisture causes the taproot to rot. A full grown tree is of moderate size and with a short straight trunk and long spreading branches forming fairly dense rounded crown. It is a moderately salt resistant tree which can grow on alkaline *usar* soils. It can be raised successfully through direct sowing.

Nutrients: It is a good fodder tree, lopped to feed small ruminants (Chaturvedi, 1948). The best lopping time varies with the climatic conditions of the locality. In general, feeding of the leaves during winter is preferred under North Indian conditions.

Digestibility coefficient for organic matter, CP, EE, CF, NFE and total carbohydrates are 53.2, 49.0, 65.0, 51.2 and 53.9 respectively.

Use of neem in animal production

Neem oil is commonly applied externally to cattle for any type of skin diseases and even on wounds. Sometimes, the animals are also made to drink oil. While grazing in marshy areas, the hooves of cattle often get septic. In this case, the hoof is washed with a decoction of Neem leaves and dressed with Neem oil; 20-30 ml of Neem oil is administered daily. Neem oil is also found effective in healing wounds of calves and in camels. Neem preparation is also found effective for various ecto-parasitic insects. A herbal compound containing *Cedarus deodara, Azadirachta indica,* and *Embelia ribes* causes 100 % mortality of poultry lice. Nimbidin present in Neem oil is highly bitter and contains sulphur. Nimbidin inhibits the growth of the fungi, such as *Tenia rubrum*, *Rhizoctonia solani, Fusarium oxysporum* and *Alternaria tenuis* and is also found to be toxic to some parasitic nematodes. Different preparations of nimbidin as an external application for the skin disorders showed

good results. Nimbin has been found to be antipyretic and non-irritant. Sodium nimbidinate, obtained from nimbin, has potent and anti-inflammatory properties. It is highly active when injected, but may be effective in large doses when given orally. When administered intramuscularly in conjective cardiac failure with anasarca, good response was observed. It has also been observed to produce uterine contractions. It reduces blood pressure and has spermicidal activity.

Neem as animal feed

Neem leaves are consumed by camels, goats and during drought by sheep and cattle also. Leaves are fed particularly to camels, which appears to relish them. Goats also eat the Neem leaves. In Rajasthan state of India, Neem growing plantations are auctioned to the shepherd for use of Neem leaves as fodder for sheep in the winter when no other vegetation is available. In Andhra Pradesh India, leaves are fed to milk yielding animals to increase the milk yield of after parturition. Neem leaves are also recommended as suitable for browsing and for incorporation into a concentrated ration after drying. It is also reported that dry Neem leaves have better nutritional quality than sorghum, which is the main dry season fodder. Neem leaves contain appreciable amount of protein, minerals and carotene and adequate amount of trace minerals except zinc. They have lower fibre content than the leaves of other trees. Fallen dry leaves have less protein and more ash and calcium than green leaves. Neem leaves contain 6.2% digestible crude protein and 52.5% total digestible nutrients. The Neem leaves have appreciable quantity of digestible crude protein and total digestible nutrients. However, cattle and buffaloes because of being bitter in taste do not relish these. Neem leaves have been fed to cattle and buffaloes up to 15-20 kg per day as maintenance ration in drought as scarcity feed. The presence of minerals in many parts and by products of Neem indicates that it is a rich source of minerals.

Bauhinia variegata

Vernacular names: *Kachnar*, *Raktakanchan*, *Kanchivola*, *Bodantam*

Distribution: It grows in Asom, Madhya Pradesh and Western parts of Indian Peninsula (Brandis, 1906). It is cultivated widely throughout the greater part of the country and in Himalayas up to height of 1500 m.

Habitat: It grows in areas, where, the shade temperature varies between 20°C and 44°C and rainfall between 500 and 2500 mm. It grows in soils ranging from gravelly soil in mountains to sandy loam and loamy soil in the valleys.

Plantation: Entire plants are planted out with balls of earth and care is taken that the roots are not injured during digging out of the plants from nursery. The spacing is about 25m x 25m.

Nutrients: The leaves are regarded as good fodder and the cultivation is advocated for leaf fodder production (Sagreiya, 1940). Average fodder yield is reported to be 15-20 kg/tree (Negi *et al.,* 1979). The chemical composition of leaves varies with the locality and season (Majumder *et al.,* 1967 a,b, ; Sinha and Jolly, 1971; Negi *et al.,* 1979). The leaves are fairly palatable. The digestibility coefficients and DCP, TDN and SE values differ with animal fed. The DCP, TDN and SE values of leaves fed to rams are 4.98,47.92 to 55.54 and 32.48 respectively.

Cordia dichotoma

Vernacular names: *Buhal*, *Bohari*, *Lasura*, *Borla*, *Challe*,*Bhoker*, *Vidi*

Distribution: It grows in sub Himalayan tract and outer ranges, up to an elevation of 1500 m and in Rajasthan, Madhya Pradesh and Khasi hills (Brandis, 1906).

Habitat: It grows in areas, where, the minimum and maximum temperature is 1° to 15°C and 35° to 49° C and the normal rainfall 250 to 300 mm. In areas with annual rainfall less than 500 mm, it thrives along streams or depressions where the moisture may be available. Deep moist sandy loam soils support its good growth while gravelly shallow and dry soils are not suitable.

Planting: Seeds are sown in June-July at a depth of 2 cm in lines spaced about 20 cm apart. Irrigation is done frequently. The germination starts in about 3-4 weeks and may take about 3 or 4 months to complete (Troup, 1921). The seedlings are kept in nursery for about 1 year before being planted in the following year with the commencement of monsoon rains. Planting is done in 0.3 m^3 pits dug in advance.

Nutrients: The leaves yield good fodder and are lopped for this purpose. The digestibility coefficients are 71,30, 58 and 76 for CP, EE, CF, NFE, respectively. The tannins account for 0.84 per cent of the DM in leaves (Lohan *et al.,* 1979).

Dalbergia sissoo

Vernacular names: *Sisam*, *Shisham*, *Tali*, *Sissoo*, *Sissu karra*

Distribution: It grows in Himalayan tract up to an elevation of about 1500 m and in Indo-Gangetic plain and Rajasthan.

Habitat: In its natural habitat, the annual rainfall varies from about 750 to 4500 mm. The absolute maximum shade temperature varies from 39° to 49 °C and absolute minimum shade temperature from about 4° C to 6°C. It has been found to be a suitable species for planting in sand dune areas of Rajasthan with only 400 mm annual rainfall (Bhimaya *et al.,* 1963).

It prefers well drained sandy loam soil with good moisture supply. It prefers freshly deposited and well drained sandy soil with pebbles and boulders in river bed (Chaturvedi, 1956 b). It can tolerate salinity to some extent.

Planting: Natural reproduction takes place through root suckers and seedlings. It can be raised by either 1) direct sowing, 2) planting out entire plant raised in the nursery, 3) stump planting, or 4) planting out root suckers. Stump planting gives better results than planting out entire plants (Kadambi and Dabral, 1955; Mathauda, 1956). The planting of one year old nursery raised seedlings or of pre-sprouted stumps gives good results (Singh, 1963). Direct sowing is done in June-July with the commencement of monsoon rains. Sowing is done in lines about 2-3 m apart. About 35 kg of broken pods are needed to sow one hectare with spacing of about 2 m (Hamfray, 1937). Irrespective of the type of planting stock, planting is done in July-August in pits of 0.5 × 0.5 m dug in advance. Planting in trenches is advocated in dry areas (Singh, 1963). Fully grown trees may attain a height of about 20 to 25 m. Some well grown trees may attain a height of about 30 m.

Nutrients: The leaves are more palatable when succulent and the palatability decreases as the leaves mature. Average digestibility coefficient for CP, EE, CF, NFE is 56, 27, 41 and 68, respectively (Sen and Ray, 1971). The leaves are fed in April-May. Once the sheep become accustomed to this fodder, their health is very well maintained (Lander and Dhannani, 1925).

Leucaena leucocephala

Vernacular names: *Subabool*, *Koobabool*

Distribution: It is distributed in Andhra Pradesh, Karnataka, Himachal Pradesh, Tamil Nadu and Uttar Pradesh (Lohani, 1979).

Habitat: It can withstand large variations in temperature and rainfall, wind and drought. It grows in tropics and subtropics. The best growth is obtained in areas with 600 to 1700 mm annual rainfall. It grows in a wide range of soil types. It grows best in deep, fertile soils, which can supply adequate moisture and abundant nutrients. It can also grow in

shallow soils. It is a leguminous fodder plant, which fixes nitrogen in the soil.

Planting: The seeds can be either broadcast or drilled in or patches. Seeds can also be raised in polythene bags. Planting out is done in July-August in 0.5 m^3 pits dug during summer. Spacing is determined by the purpose of raising the plantation. Spacing between the rows may vary from as narrow as 0.3 m for forage to as wide as 3-4 m in case of intercropping.

Nutrients: Livestock relishes the foliage. High mimosine content limits its use as sole feed for sheep. It can be fed up to 15 per cent of the fodder to sheep. The chemical composition of the leaves varies in different months and is influenced by edaphic and climatic changes (Singh and Mudgal, 1967). On the basis of chemical composition and digestibility of different nutrients, *Leucaena* leaves are slightly inferior to lucerne leaves (Kharat *et al.,* 1980).

Prosopis cineraria

Vernacular names: *Khejri*, *Khejra*, *Jand*, *Shami*, *Jambi*, *Shema*

Distribution: It is found in Gujarat, Haryana, Punjab, Rajasthan and Western Uttar Pradesh (Kaul and Ganguli, 1962).

Habitat: This plant can grow very well in sandy soils, where the annual rainfall is less than 500 mm, the maximum shade temperature varies from about 48° to 52°C and the minimum temperature during winter touches about-4 °C. It can grow up to a height of 10-13 m. In its natural range, it grows on coarse sandy soils (Sharma, 1966; Bawa *et al.,* 1988).

Planting: The plants are raised in the nursery in polythene bags of 10 × 30 cm size, containing following mixture

Pulverised soil	2.5 kg
Compost manure	2.5 kg
Single super phosphate	0.5 kg
D.D.T.	0.05 kg
Urea	0.125 kg

The seed is sown about 1 cm deep. The growth of the seedling is slow and even under irrigated conditions they may seldom attain a height of 30 cm in one year (Wadhani, 1953). It is planted during rainy season when the plant is 25-30 cm tall. About 40-50 trees per hectare are planted. It drains moisture not only from the upper 2 m soil layer, but also from lower layer below kankar zone (Krishnan *et al.,* 1968). It

is watered twice in a month. Light prunning is done when the plant is 2 to 2½year old.

Nutrients: It is an evergreen or nearly so. Its pods ripen from May to June. A mature plant can yield 40 to 50 kg of green leaves, which on dry matter basis contains CP 31.1 per cent, CF 12.8 per cent, EE 2.2 percent and NFE 53.0 per cent. An adult ewe can consume green leaves @ 4-5 per cent of its body weight. The dry matter consumption in case of adult Chokla rams was reported to be about 2.18 per cent of its body weight (Bhandari *et al.,* 1979).

Ziziphus mauritiana

Vernacular names: *Beri*, *Bel*, *Bordi*, *Elangi*, *Barboli*, *Reegu*

Distribution: It grows throughout India except temperate Himalayas and very humid areas of North East India.

Habitat: It is a hardy tree and can grow under varying climatic conditions and even in conditions where most other trees will fail to grow (Singh *et al.,* 1967). The average maximum and minimum temperature range in which it grows is 8 to 39 °C and -7 to 13 °C and annual rainfall 125 to 2225 mm (Troup, 1921). It grows in laterite, black cotton and moderately saline soils (Hussain, 1977). Its best growth is obtained on deep sandy loam soil, which is neutral or slightly alkaline (Singh *et al.,* 1967).

Planting: The seed can be sown either in furrows or in dug up lines, spaced 3 to 5 m apart in July after the commencement of monsoon rains.

Nutrients: The leaves are a good fodder for cattle, sheep and goats. The average digestibility coefficients for different chemical constituents are CP, 36; EE, 62, CF, 27 and EE, 34. The total digestible nutrients per tonne of dry fodder are 306.65 kg and the nutritive ratio is 9.9. The leaves thus have fairly high nutritive value. The composition of *Z. nummularia* leaves has been estimated by Malik and Nath (1970).

Plant Poisoning

Sometimes, heavy mortality can occur amongst sheep owing to the grazing of poisonous plants which they are forced to consume during scarcity periods or when new animals not accustomed to local environment, are introduced. Katiyar (1962-1968) reported 233 (6.3 per cent) deaths due to poisonous plants and listed 32 such plants and grasses as were reported poisonous for sheep. Some of these are new leaves and buds of Oak, new shoot of *Pieris ovalifolia,* leaves of *Storbilanthes wallichii* and new leaves of *Rhododendron campanulatum*

and flowers of *Kalnchoe spathulata*. The tender leaves and honey of *Rhododendron arboreum* are toxic and the symptoms observed are frothy saliva and grinding of teeth (Kehar and Rao, 1944).

Lal and Kalra (1960), Sastry and Mahadevan (1963) and Katiyar (1964) reported that *Lantana camara* causes poisoning in sheep resulting in the symptoms of photosensitization and severe icterus. Katiyar (1961a) also reported that mature arunja pods contained hydrocyanic acid. Cases of hydrocyanic acid poisoning in sheep owing to the ingestion of leaves of *Sorghum halepense* were also reported by Bawa (1943) and Katiyar (1961b). The adverse affects of tannings are given in Table 16.3.

Pasture Establishment

Some pasture species can be established without seedbed preparation and tropical legumes have been successfully established in this way. Generally, however, some seed bed preparation is needed prior to seeding and the better seedbed preparation, the better the result.

Preparation of land

Pasture can be established on prepared seedbed. Better the seedbed preparation, the better the pasture establishment. Finer seed bed is required for small seeds. The larger seeded legume species such as *Lablab purpureus* and *Siratro* can be satisfactorily established with a minimum of seedbed preparation.

Pasture establishment is usually more successful on new land because of the higher initial fertility after recent clearing and less competition from weed growth. The first cultivation should be given by a heavy duty stump jump disc plough which can remove the remaining small stumps and roots and prevent a good deal of bush regrowth. Then disc harrows are used to chop small pieces of root and stems. If a finer and more level seedbed is desired, a subsequent harrowing can be given. For small areas, row seeding may be accomplished with a hand planting machine. Canvas bags holding 2-4 kg seed hanging from shoulder and seed covering the chest are attached from which the seed can be taken out and broadcast

Selection of seeds: *Cenchrus, Lasiurus* and Elephant grasses are good for sowing in arid and semi arid areas. Sowing leguminous fodders such as *Dolichos*, *Siratro,* etc can increase the nutrient contents of these. Mixed pastures have been found to be good for sheep.

Seed rate: About 6-7.5 kg of *Cenchrus* seed and 30 kg of Butter fly pea is sufficient for one hectare.

Table 16.3. Adverse effects of tannins present in top feeds

Fodder tree/shrub Predominant	Tannin	Animal	Nutritional effect	References
Acacia aneura	CT	Sheep	Reduction in N digestibility, decreased wool yield and growth, decreased S absorption	Pitchard *et al.,* 1988
A *angustissima*	HT	Goat	Decreased *in sacco* N digestibility	Ahn *et al.,* 1989
A *cyanophylla*	CT	Sheep	Reduced feed intake, negative N digestibility, loss in weight	Reed *et al.,1997*
Anilotica (pods)	CT	Sheep	Low growth rate, reduced N and NDF digestibility	Tanner *et al., 1990*
Asaligna	CT	Sheep	Reduction in body weight	Howard *et al.,* 2002
Asieberiana (pods)	HT	Sheep	Low growth rate, reduced N and NDF digestibility	Tanner *et al., 1990*
Albizzia chinensis	CT	Goat	Reduced *in sacco* N digestibility	Ahn *et al., 1989*
Bauhinia variegata	CT	Cattle	Reduced *in sacco* dry matter loss	Makkar *et al., 1989*
Caliandra calothrysus	CT	Goat	Reduced *in sacco* N digestibility	Ahn *et al., 1989*
Ceratonia siliqua	CT	Goat	Reduced protein digestibility	Silanikove *et al.,* 1996
Eugenia jambolana	HT	Goat	Reduced feed intake, weight loss	Panda *et al., 1983*
Larrera tridentate	c1	Goat	Reduction in feed intake, digestibility and N retention	Holechek *et al., 1990*
Prosopis cineraria	CT	Sheep	Reduction in feed intake, protein, digestibility, decreased wool yield & growth, decreased Fe absorption	Prasad *et al.* ,1996,97 Kumar,1983
P. grandulosa	CT	Goat	Reduced feed intake, digestibility and N retention	Holechek *et al.,* 1990
Quercus gambelii	CT	Goat	Reduced digestibility of cellular constituent and increased faecal N	Nastis and Malechek, 1981

Table Contd.

Table 16.3. *Concluded*

Fodder tree/shrub Predominant	Tannin	Animal	Nutritional effect	References
Q.grisea	CT	Goat	Reduction in feed intake digestibility and N retention	Holechek *et al.,* 1990
Q.incana	HT	Cattle	Reduced dry matter, digestibility and N retention	Makkar *et al.,* 1989
Robinia	CT	Sheep	Reduced protein digestibility,	Ayers *et al.,* 1996
pseudoacacia		Goat	and reduced feed intake and negative ADF digestibility	
Salix tetrasperma	CT	Cattle	Reduced dry matter loss *in sacco*	Makkar *et al.,* 1989
Terminalia oblongata	HT	Sheep	Reduced in feed intake toxicity but no effect upon digestibility,	Mc Sweeney *et al.,* 1988,
Ziziphus	CT	Sheep	Reduced feed intake, protein and	Bhatia *et al.,* 1999
nummularia			DM digestibility, decreased wool yield and weight loss	Kumar and Singh 1984b

Sowing: Depth of planting depends on seed size. Very small seeds should never be covered but broadcast on the surface; large seeds can germinate from deep planting. The usual planting depth is 1 to 2.5 cm for most species. Most seeds are planted dry just ahead of the expected rainy season. Seeding after rain is more successful with large seeded legumes. *Cenchrus* is sown in July- August. There should be a distance of 0.5 m. between rows and between plants in case of *Cenchrus* and Butter fly pea. The sowing is done in strips of 2-3 rows.

Irrigation: It is impossible in pastures. Only water can be conserved; small bunds can be made against slopes. If there is depression in the field, it can be deepend further to store water for future irrigation.

Harvesting and grazing: The sheep are not allowed to graze upto one year of the establishment of the pasture. The grass should be harvested after the seed shedding in first year. This helps in the establishment of the pasture. The grass should be cut 10 cm above the ground. This helps in profuse tillering. The sheep should be allowed to graze in the second year in the month of August when the grass is 25 to 30 cm in height. Rotational grazing is very useful. This saves sheep from diseases, which spread through dung. If the production falls, grazing should be stopped for a year or two.

Lambs should be allowed to graze first, followed by lactating ewes and dry ewes should be allowed to graze in the end.

Grasses

Avena sativa

Vernacular name: Oats

Habitat: It is grown in Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Maharashtra, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. It can be grown in irrigated and unirrigated places. It can be grown in places where the general atmospheric temperature varies from 21 to 24°C.

Sowing: It is sown in October in Northern India. Irrigation is done 3 weeks after sowing and subsequent irrigations are done at an interval of 2 to 3 weeks. Irrigation is done after every cutting.

Fodder: First cutting is done 50 to 60 days after sowing. It yields 400 to 450 quintal green fodder in two cuttings.

Nutrients: It has 10 to 20 per cent protein. It has 32 to 38, 360, 44,1.60 to 2.30 and 9.30 to 13.90 per cent CF, NFE, EE and total ash, respectively on dry matter basis.

Brachiaria rimosa

Vernacular name: Kurra

It is a very good fodder crop. Human beings also consume its grains. It is cultivated in Ajmer, Pali, Sirohi and Udaipur districts of Rajasthan. It can be used in crop rotation as follows:

Wheat - *Kurra* - *Methi*
Barley - *Kurra* - *Methi*
Cotton - *Kurra* - *Wheat*
Cotton - *Kurra* - *Methi.*

It is normally sown after the harvesting of wheat crop. It can be sown at the onset of rainy season also. It can be sown in sandy or loam soil. Accumulation of water is harmful for the crop. One or two ploughings are sufficient for this crop. 20 to 25 cartloads of sheep manure are needed per hectare.

Method of sowing: After broadcasting, the field is ploughed and small plots are made for irrigation. Eight to ten kilogram seed is sufficient for a hectare if it is sown for dry fodder and grains. It is sown for green fodder; 13 to 28 kg seed is required per hectare.

Irrigation: If the crop is sown in April/ May, first irrigation should be done immediately after sowing. Irrigation is done every fortnight.

Fodder: It becomes available for fodder after 1 to 1½ months of sowing. Three cuts can be taken in three months. For crop sown in May harvesting is completed by July, if it is sown in July, harvesting is completed by September. One hectare plot yields 300 quintals of green fodder.

Brachiaria mutica

Vernacular name: Para grass

Habitat: It is also called Buffel. This was imported from Ceylon in 1894. Humid climate of Bombay, Kerala and Karnataka suits it well. It grows well on the banks of rivers, in humid climate where the atmospheric temperature is 32°C and above. It can grow on saline land also.

Sowing: Cuttings having 2 to 3 inter nodes are sown at a distance of 15 cm in spring in irrigated areas and in the beginning of rainy season in unirrigated areas. 30 to 40 cartloads of organic manure are added to ordinary soil before sowing and 70 kg ammonium sulphate after second or third cutting.

Fodder: It gives fodder throughout the year upto 5 to 7 years. Fodder production per hectare is 375 quintals. After every cutting, 25 to 30 kg nitrogen containing fertiliser per hectare is applied.

Nutrients: Its nutrients differ according to locality in which it is grown. Its CP varies from 2.8 to 16.1 per cent, CF from 28 to 34 per cent, NFE from 41 to 57 per cent and EE from 0.9 to 3.9 per cent. Singh *et al.* (1963) determined the chemical composition of *B.mutica* leaves (Table 16.5).

Table 16.5. Digestible nutrients of grasses

Botanical name	Common name	DCP	TDN	SE	References.
Tribullus terristriss	Gokhru	3.2	12.9	8.9	Shukla and Ranjan , !969
Brachiaria mutica	Para grass.	1.2	18.0	13.5	Joshi and Ludri, 1967
Panicum kabulabula		1.3	26.2	17.8	Joshi and Ludri, 1967
Brigival		2.1	12.5	11.5	Joshi, 1966.
Carthamus tinctorius	Kerr	2.0	12.7	10.4	Ranjan *et al.,* 1959
Chiabate	Ipomoea	1.5	10.3	9.0	Talpatra and Bansal, 1959.

Chloris gayana

Vernacular name: Rhodes grass

Habitat: This was first brought from South Africa in 1915. It has become very popular. It can grow well under drought conditions and can survive in cold also. It can tolerate saline soil to some extent.

Sowing: It can be sown in spring if irrigation facilities are available, otherwise, it can be sown in the beginning of rainy season by using stem cuttings having roots. About twentyfive thousand stem cuttings are needed per hectare. It should be irrigated every 2-3 weeks. It can also be grown by sowing seeds.

Fodder: First cutting can be taken after 2½ months after sowing, thereafter, it can be cut at monthly intervals up to 7-8 times. Fodder production per hectare is 275 quintals.

Nutrients: The grass is leafy and palatable. It can be fed as chaffed fodder or can be grazed. It contains 5 per cent protein.

Clitoria ternatea

Vernacular name: Butterfly pea, Kordofan pea

Distribution: It is a native of tropical America, widely grown as leguminous fodder (Bermudez *et al.,* 1968).

Habitat: It is summer growing perennial, low frostbite tolerant, can climb tall grasses. Grows in areas where the annual rainfall varies between 400 and 1500 mm. It is fairly drought tolerant (van Rensburg, 1967), but also performs well under irrigation (Barran, 1953; Parbery, 1967). Adapted to a wide range of soil conditions from sandy to deep alluvial loams and heavy black cracking clays (Lee, 1954). It is tolerant to high pH soils.

Yield: First cutting is done 2½ months after sowing. van Rensburg (1967) obtained a yield of 33.3 quintal/ha of dry matter. Parbery (1967) obtained yield of 133.50 quintal/ha/year on Cununnura clay under irrigation. It is very palatable. Its drought resistance is also an asset

Lablab purpureus

Vernacular name: Carpet bean, Sem

Distribution: Widespread throughout the tropics

Habitat: It grows as summer growing annual, biennial or shor term perennial. It requires warm temperatures for good growth. Minimum temperature for growth is about 3°C (Murtagh and Dougherty, 1968). It is more tolerant to cold than velvet bean. It is quite drought tolerant when established (Luck, 1965). It is sown in early summer.

Yield: Dry fodder yield varies from 25-40 tonnes / ha (Crowder, 1960; Van Rensburg, 1967).

Nutrients: French (1937) reported 11.74 per cent crude protein, 37.67 per cent crude fibre and 39.47 per cent carbohydrates. Luck (1965) reported 25 to 26 per cent crude protein in leaf. Digestibility figures for sheep are more than 50 per cent. The palatability of the hay (French, 1957) and silage (Ryley, 1966) for sheep has been recorded. Sheep ate the silage readily at approximately 1 kg/head/day.

Macroptelium atropurpurium

Vernacular name: Siratro

Habitat: It is a summer growing perennial with greatest growth in mid summer to autumn. The temperature for optimum growth varies from 26.0 to 30°C. It requires at least 615 mm and preferably more than 850 mm of rainfall.

Yield: Van Rensburg (1967) obtained an average dry matter yield of **79.6 quintal/ha**

Nutrients: Milford (1967) gave the analysis of mature Siratro at the seed shedding stage. He recorded figures of 35 per cent dry mater, 16.8 per cent crude protein, 33.4 per cent crude fibre, 1.2 per cent ether extract, 38.8 per cent nitrogen free extract and 9.8 per cent ash.

The digestibility figures were 50.4 per cent for dry matter, 53.4 per cent for organic matter, 67.6 per cent for protein, 50.9 per cent for fibre and 50.6 per cent for nitrogen free extract. It is very palatable.

Mucuna prurients var utilis

Vernacular names: Velvet bean, Bengal bean

Distribution: Probably native to southern Asia and Malaysia, now widely distributed in tropics.

Velvet beans require a hot, moist climate for maximum growth. They grow from sea level to 2100 m. The rainfall range of the species varies from 650 to 2500 mm. Tolerates a wide range of soils from sands to clays and will grow on soils of appreciable acidity.

Yield: King *et al.* (1965) stated that a crop of velvet beans yielded 17.4 tonnes of green fodder per hectare.

Nutrients: Axtmayer *et al.* (1938) had the plants analysed when in flower and also the pods. The plant contained 15.65 per cent crude protein and 34.47 per cent crude fibre. French (1935, 1937) found that the velvet bean hay contained 17.84 and 12.95 per cent crude protein and 10.88 and 7.12 per cent digestible protein, respectively.

Pennisetum perpureum

Vernacular names: Elephant grass, Napier, Hathi grass.

It grows well in loam or sandy loam soil with good drainage. Saline soil is not good for it. It is a good fodder crop which can give green fodder throughout the year for several years. It attains a height of 2.5 to 3.0 meter. Its leaves resemble those of maize.

Sowing: It can be sown from February to July. Its small stem pieces are sown like sugarcane. These pieces are sown at a distance of 0.5 m, row to row distance is 1.0 m. It can also be sown, with lucerne or velvet beans. About 20-25 thousand pieces are needed per hectare. Humid and hot humid climate is good for this crop. It continues to give fodder up to 5-6 years. About 6 cuttings per year produce 250-300 quintals of

green fodder. If the soil is fertile and climate favourable, it can yield 600 quintals of fodder in 6-8 cuttings.

Nutrients: It has 22 per cent dry matter, 6.3 per cent protein and 12.5 per cent digestible nutrients. It is better than Napier. The height of the plant is 3.0 m.

Sowing: Fifty carts of organic manure, 2.5-quintal superphosphate, 1.5 quintal calcium ammonium nitrate and ammonium sulphate is put per hectare. Then the field is ploughed 2-3 times. Pusa giant Napier are sown at a distance of 75 cm in February. Then they are covered with soil and watered immediately. Two to three irrigations are done at weekly intervals and there after at fortnightly intervals. About 15-20 thousand stem cuttings are required per hectare.

Fodder: The first cutting can be taken by the middle of May. Thereafter, cuttings can be taken every 40-50 days. Fertilizer should be added to soil and irrigation should be done 10-15 days after second cutting for better growth. A plant can give fodder for 2-3 years

Nutrients: The fodder is nutritious and palatable.

Pennisetum pedicellatum

Vernacular name: Dinanath grass

Habitat: It is an annual, which grows in arid and semiarid areas, where the rainfall varies between 500 and 1000 mm. It is grown in Andhra Pradesh, Bihar, Bengal, Odisha and Tripura. It is also grown in parts of Asom, Gujarat, Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Tamil Nadu and Uttar Pradesh. Loam and sandy loam soil is good for its growth. It can be grown in poor soils also but growing in fertile soils is beneficial.

Sowing: It is best sown in June-July. It can be sown in March-April in irrigated places. It is sown in rows. Plant to plant distance is 25 cm. Seed can be broadcasted. About 10-12 kg seed is required for a hectare. It needs one irrigation in November, if sown in rainy season. Summer sown crop needs irrigation at an interval of 10-15 days.

Fodder: It is first harvested, 70-80 days after sowing. It can be cut at flowering stage for second cutting. It can yield 600-700 quintal of green fodder per hectare.

Nutrients: It is palatable fodder, grazed by sheep, goat and cattle. Nutrients vary according to age of the grass. At 30, 45, 60 and 80 days it has CP 19.0, 10.0,5.7 and 3.4, per cent, respectively. CP may be 25-

33 per cent. Similarly DP, EE, CP, NFE are 50, 63, 65 and 62 per cent, respectively.

Vigna unguiculata

Vernacular names: Cowpea, *Lobia*, *chola*

Distribution: The country of origin is uncertain. Vavilov (1951) thought it might be India with secondary centers in China and Ethiopia. It is widespread throughout tropics and subtropical areas. It is grown in summer. It is herbaceous annual with twining stems.

Yield: Heavy grazing should be avoided. At no time should be grazed or cut before flowering. Milford and Minson (1968) found that cowpea yielded 23.1 quintal DM/ha in summer and 40.7 quintal DM/ha in autumn and early winter.

Nutrients: The crude protein contents of cowpea were 13.01 per cent and digestible crude protein 7.92 per cent. For first day or two, the sheep may shun the crop, but when they become accustomed to it, they will eat it readily. In addition, the chemical composition of *Anagallis arvensis* (Upadhyaya *et al.,* 1971); Bajra Orientale (Bhatia and Munshi, 1972); *Brachiaria mutica* (Singh *et al.,* 1963); *Cassia tirra* (Gupta *et al.,* 1970); *Chicorium intybus* (Shukla *et al.,* 1970 b); *Clitoria ternatea* (Katiyar *et al.,* 1970); *Cyanodon dnctylon* (Pachauri *et al.,* 1970); *Dactyloctenium aegyptium* linn (Katiyar and Ranjhan, 1969a); *Dendrocalamus strictus* Oayal, 1966); *Digitaria decumbens* (Kulshreshta *et al.,* 1971); *Grewia oppositifolia* (Sharma *et al.,* 1966b); *Indigofera cordifolia* and *I. ennenphyla;* (Nath and Malik, 1968); and *Morus indica* (Narayana and Setty, 1977); *Pennisetum clandestinum* (Katiyar and Ranjhan, 1969b); *Pennisetum purpureum* (Singh *et al.,*1965); *Panicum maximum* (Saxena *et al.,*1972); *Phaseolus atrpurpureus* (Saxena *et al.,*1971); *Rhynchosia* minima (Shukla *et al.,* 1970a); *Glycine max* Oohri *et al.,* 1971); *Vigna sinensis* (Singh and Patnayak 1977b) and *Ziziphus nummularia* (Malik and Nath, 1970) has been determined.

Crop Rotation

As the pasturelands are shrinking day by day and an average farmer does not have more than 5 acres of land, the only method left is growing nutritious fodder for livestock. By adopting any of the following crop rotations, sheep farmers can get green nutritious fodder through out the year.

Napier-Lucerne

Napier × Bajra cross No. 21 and Lucerne can be sown in strips. This will give fodder throughout the year.

Sorghum-Berseem -Maize

Improved varieties of sorghum such as J. L 263 and J.S 29/1 can be sown in the last week of June. It can be harvested after 80 to 90 days. Then Berseem can be sown in mid October. After taking 5-6 cuts, maize can be sown in April, which can be harvested by June.

Sorghum-Oats-*Bajra*

After harvesting sorghum in mid October, H.F.O 114 variety of oats can be sown. Two cuttings of oats can be taken. Then fast growing varieties of *bajra* (S 530 or S 1/3) can be sown.

Sudan grass-Berseem-Maize

Sudan grass is a high yielding crop, which can give 5-6 cuttings. Then berseem can be sown in October. Maize can be sown in April.

In addition to these there are many fodder crop rotations by following these sheep farmers can get green fodder for their animals throughout the year. Package of practices for increasing fodder production are given in Table 16.4.

Table 16.4. Some suggested crop rotations

Months	Crops which can be sown	Crops which can be harvested
December and January	Oats	Berseem, Lucerne, *Sarson*
February and April	Sudan grass, Cowpea, Maize	Berseem, Luerne, Oats
May and June	Maize, Sorghum, *Bajra*	Lucerne, Maize, Sudan grass
July and August	Sorghum, Maize, Cowpea, Sudan grass, *Bajra*	Maize, Sorghum, Cowpea, Sudan grass, *Bajra*
September	Lucerne, *Sarson*	Maize, Sorghum, *Bajra,* Sudan grass
October and Nov.	Lucerne, Berseem, Oats, *Sarson*	Sorghum, Sudan grass

Fodder Management during Drought

The final production of forage crops in any one year depends upon several man made and natural factors. One of the most important natural factors is the total rainfall during that year. The distributions of rainfall over a year also have a significant effect on forage crop production; this calls for long term planning.

The major challenge in unirrigated areas is to minimize yearly variations in forage production and to maintain production at a reasonably acceptable level. The crops usually face moisture stress of

various intensities at one stage or other during the growing season. To mitigate the adverse effects of drought, strategic approaches should be adopted. The strategic approaches are of long term in nature to efficiently conserve and utilize rainwater.

Rainwater harvesting can be defined as the collection of runoff rainwater from treated or untreated land surface and storing it in open reservoir or in soil itself. Runoff agriculture was developed almost 4000 years ago and the lands receiving as little as 110 mm annual rainfall were used for crop production. The harvesting of water from roof tops and rocky terrains, artificially made in structures called *Tankas*. The *Khadin* cultivation is the best example of runoff farming in western Rajasthan

Water harvesting techniques have two components- the runoff area and the run on area. Runoff area is where rainfall is concentrated as surface runoff and run-on area is small lower-lying runoff receiving area. The run-on area is also termed as cropped area or cultivated area. Run on area often consists of agricultural fields or plots trapping large amount of water, embanked to facilitate their infiltration. As a result, water to plant available increases and allowing agricultural production in areas that normally do not receive surface rainfall.

The magnitude of runoff generation in the catchments area depends on rainfall characteristics (among others rain intensity and duration), soil properties (e.g. texture, surface roughness due to vegetation and stoniness) and topography (Ben Asher *et al.,* 1985, Yair, 1983). This is expressed in runoff efficiency, i.e. the ratio of runoff volume to precipitation volume averaged over a year to discount variability due to storm size (Fink *et al.,* 1979). Runoff efficiency increased with runoff intensity, fineness of soil texture, steepness of slope, but decreases with catchments size (Evenari *et al.,* 1992). In large catchments surface runoff covering longer distance thus implies a longer retention time during which runoff water is infiltrated into soil. In general, runoff production increases with size of the catchments area.

Micro-catchments: It covers an area of less than 5 ha having gentle slope. Micro-catchment responds rapidly to rain including light showers, by generating small amounts of runoff and that generally does not create erosion problems.

Macro-catchments: Due to lower runoff efficiency inherent to large a catchment areas, macro-catchment generally produces runoff less frequently than micro-catchment, though at large volumes with additional erosion hazard. The occasional production of large amounts of runoff requires macro-catchment systems.

Runoff inducement: The desired characteristics of catchment area for increasing runoff volume are (Myers, 1975).

The surface of the catchment areas should be relatively smooth and impermeable to water. The treated catchment area should have a high resistance to weathering (hot and cold) and traffic, moderate flow of water etc. The treatment should be able to resist damage by hail, intense rainfall, wind, occasional animal traffic, moderate flow of water etc. The treatment should be inexpensive on an annual cost basis and should permit minimum site preparation and construction costs. Maintenance should be simple and inexpensive. There are three ways to modify catchments area for increasing runoff volume: topography modification, soil modification and impermeable coverings (Frasier, 1994).

Water Harvesting Techniques

The water harvesting techniques may be broadly classified into two categories:

a) *In situ* water harvesting where water is stored in the soil profile.

b) Catchment water harvesting where water is stored in a reservoir or ponds for recycling when needed.

Inter-row water harvesting: Under this system, furrows of about 30-40 cm width (15 cm deep) are alternated by ridges of 60-70 cm. Ridge makers, at right angle to the field slope, lays out the furrows and ridges. This reduces runoff and at the same time, water is concentrated in furrows causing better water availability. Inter-row method is particularly suitable for medium to heavy textured and deep to moderately deep soils.

Inter-plot water harvesting: In inter-plot water harvesting, the runoff water is contributed to cropped plots by adjacent bare plots either on one side or both sides. These adjacent plots are provided with certain slopes to augment the runoff water towards cropped plot for increasing available moisture in the soil profile to saturate the root zone. In this system, kit is necessary to ascertain the ratios between cropped area and catchment area, together with optimum slope; depending upon soils characteristics and rainfall pattern of the region.

Bench terrace water harvesting system

The system uses most of the principles of runoff farming to conserve and utilize runoff for grain production. This system can be used for forage production also. The conservation bench terrace system uses level contour benches with terrace ridges to control erosion and retain, spread and infiltrate storm runoff from cultivated contributing areas that are not treated to increase runoff.

Table 16.6. Chemical composition of grasses on dry matter basis

Botanical name	Common name	DM	CP	CF	EE	NFE	Total ash	Cal cium	Phos phorus	References
Amaranthus spinosa	Goja	-	16.13	20.29	2.51	42.12	18.89	2.28	2.28	Singh and Joshi, 1957
Andropogon annulatus		Young	9.70	33.06	1.81	42.51	13.58	-	-	Mathur, 1960
Andropogon contortus	Speargrass	50.00	1.87	11.12	0.26	-	2.00	0.12	0.12	Chucko, 1954
Andropogon Muricatus		Ripe	4.84	36.60	1.18	44.18	12.60	-	-	Mathur, 1960
Briflchiaria ramosa	Kura	-	9.43	28.53	0.78	43.92	-	-	-	-
Cenchrus ciliaris	Dhaman	Ripe	11.42	27.20	1.87	41.14	18.10	-	-	Mathur, 1960
Cynodon dactylon	Doob	Ripe	4.84	36.60	1.18	44.18	12.6	-	-	Mathur, 1960
Cypents iria	-	Ripe	6.04	32.77	6.89	51.69	8.61	-	-	Mathur, 1960
Dicanthium annulatum	Karad	-	2.40	35.77	2.01	49.84	-	-	-	-
Garthamus tinctoris	Kerr	-	12.40	30.89	1.94	44.37	-	-		Ranjan *et al.*, 1959
Heteropogon contotus	-	Young	5.00	34.24	1.36	47.70	11.64	-	-	Mathur, 1960
Ischeum rengachuniflnum		-	60.0	1.90	13.27	0.87	-	2.22	0.20	0.05 Chucko, 1954
Lasiurus sindicus	Seven	-	5.98	30.08	-	44.73	-	-	-	-
Panicum sauilatis			7.47	31.64	2.01	59.19	-	-	-	Mathur, 1960
Panicum antidotale	Blue panic	Ripe	7.21	40.07	1.91	43.11	7.07	-	-	Mathur, 1960
Panicum colanum		Ripe	7.26	40.47	1.19	43.11	7.79	-	-	-
Panicum maximum		Ripe	7.69	37.33	1.67	39.44	13.89	-	-	Mathur, 1960; Sexena *et al.*, 1972
Pennistetum flacidum		21.15	11.36	30.40	1.97	45.07	11.21	0.34	0.30	Venkatachalam, 1960
Tribukus terestris	Gokhru	-	12.10	27.80	2.60	40.80				

Table 16.7. Digestibility of dry matter and crude protein contents of some grasses and legumes.

Species	Dig. DM (%)	C. P. (%)	References
GRASSES			
Brachiaria mutica	55-61	6.5-132	Combellas and Gonzalez, 1973
Cenchrus ciliaris	60-77	8.6-17.3	Combellas and Gonzalez, 1973
C. ciliaris	44	9.7	Singh, 1975
Chloris gayana	62-67	-	Me Leord and Minson, 1974
C. gayana	48-63	4.9-13.1	Minson, 1972.
C. gayana	-	8.2-17.0	Ruxton, 1975
Cynodon dactylon	47-53	9.1-11.7	Combellas *et al.,* 1972
C. dactylon	-	8.4-9.6	Ruxton, 1975
Digitaria decumbens	39-63	-	Funes, 1975
D. decumbens	66	7.2	Kulshreshtha *et al.,* 1972
D. decumbens	49-67	6.0-14.9	Minson1972
Hyparrhenia spp	54	6.5	Gihad, 1976
Panicum maximum	47-64	6.4-16.0	Minson, 1972
Paspalum dilatatum	43-59	5.9-13.3	Minson, 1972
Pennisetum clandestinum	47-62	5.9-17.3	Minson, 1972
P. purpureum	61	4.5	Lima *et al.,* 1972 a
Setaria anceps	60	10.5	Shanna *et al.,*1972
S. splendida	63-66	-	Mc Leord and Minson, 1974
S. splendida	51-67	5.7-13.6	Minson, 1972
LEGUMES:			
Desmodium uncinatum	47-54	10.9-18.2	Milford, 1967.
Lablab purpureus	56	14.4	Hendricksen *et al.*, 1981.
Lotononis bainesii	60	20.0	Milford, 1967.
Macropitilum atrorpureum	42-71	13.8-18.0	Lima *et al.*,1972b
M. atropurpureum	50	16.8	Milford, 1967.
M. atropurpureum	55	16.7-23.0	Saxena *et al.*, 1971
M.lathyroides	42-62	7.6-19.2	Milford, 1967
Stylosanthes guianensis	57-64	12.4-13.7	Ademosun, 1970
S. guianensis	48	11.8	Milford, 1967
Trifolium alexandrinum	68	20.6	Sharma and Murdia, 1974
Vigna vexillata	58-69	16.2-20.3	Milford, 1967

Table 16.8. Different varieties of fodder crops recommended for different parts of the country

	Recommended	in	Green fodder yield (q/h)	Remarks
Berseem	Mescavi	All parts where berseem is sown	800-900	Can tolerate high temperature
	Pusa Giant	-do-	900-1000	Gives more production at lower atmospheric temperature, leaves bigger in size, succulent
	B.L.1	Punjab	800-900	Capable of giving fodder upto late stage
	S.91 1	All region where berseem is grown	1000	Grows well even in places, where the temperature is low
	J.B.1	-do-	1000	Regeneration good, can be grown in places where the temperature is either low or very high
	C. 3 94	M.P., U.P., Haryana, Punjab	1000-1050	Fast growing, gives fodder for longer period
	U.P.O. 102	Throughout India	900-1000	Can tolerate high or low temperature, gives fodder for longer periods
	U.P.O. 103	-do-	9000-1000	-do-
	B.L. 10	Punjab	1000	Higher fodder and seed yield
Cowpea	Russian Giant	Plains of Northern India and Assam	350-400	Late maturing, good height and branching
	E.C. 4216	Plains of Northern India	300	Medium duration. growth as for Russian giant
	F.O.S.1	Haryana, Punjab, Delhi	250	Medium duration, stems erect
	H.F.C.1	Throughout India	300	Matures earlier, stem erect, bushy
	No.10	Haryana, Punjab, Delhi	200	Stem erect, medium duration

Table Contd.

Table Contd.

Name of crop	Varieties	Recommended in	Green fodder yield (q/h)	Remarks
	S. 450	Throughout India	250	Fast growing, good for summer, early maturing
	S. 457	Throughout India	250	Fast growing, early maturing
	C. 26	Throughout India	350	Multicuts, resistant to diseases
	J.C.1	M.P., U.P.	300	Dark green, Geapertype
	U.P.C.	Southern India	350	Medium duration, dark green, resistant to diseases
	U.P.C. 5286	Throughout India except S. India	400	Medium duration, darkgreen, resistant to diseases
Dina Nath	P.P.3	Haryana, Punjab, M.P., U.P.	400	Fast growing, succulent, leafy, early maturing
	P.P. 10	Warm climate provinces	450	Late maturing
	P.P. 15	Warm climate provinces	450	Medium duration, leafy, fast growing
	Pusa 38	Warm climate provinces	500	Fast growing
	Pusa 3	Warm climate provinces	500	Fast growing
	P.P. 47	Warm climate provinces	500	Fast growing
	S. 3808	Warm climate provinces	500	Fast growing
	JP 12	Warm climate provinces	510	Fast growing
Gaur	No 2	All guar growing areas	175	Plants dwarf, more grains and more branching
	FS 277	All guar growing areas	225	Plants, tall, more fodder, grain production less
	Durgapura white	All guar growing areas	175	Plants dwarf, branching, good for grains

Table Contd.

Table Contd.

Name of crop	Varieties	Recommended in	Green fodder yield (q/h)	Remarks
T-3		All guar growing areas	175	Early maturing, not good for grains
	HF. G. 119	All guar growing areas	250	Plants tall, leafy, good for fodder and grains
	G.L. 6	All guar growing areas	250	Medium height, good for fodder and grains
Lucerne	T.8	Northern,North west and central all India	600-650	Good for places, where it is sown every year, leafy fast growing
	T.9	Throughout India	800-1000	Fast growing, disease resistant
	Anand 1	Gujarat, Maharashtra	800-1000	Fast growing and disease resistant
	Anand 2	Gujarat, Maharashtra, Haryana	700-800	Fast growing, disease resistant and regeneration
	Coirnbatore	Tamil Nadu, A.P.	800-1000	Disease resistant, fast growing after cutting good for seed production
Sonadi	F.O.S. I	Dry regions of Northern India	400	Good leguminous fodder
	No. 76	Haryana, Punjab, Delhi, . Western U.P	450-500	Late maturing, leafy, dark green colour
Metha	T. 8	Punjab, Haryana, Western U.P	350-400	Leaves broad, good for late sowing
Makchari	-	Throughout India	500-600	Multicut
Bajra	H.B.S	Throughout millet growing areas	500-600	Plants tall, leafy, profuse tillering
	H.B.S	Throughout millet growing areas	500-550	Leafy, tall, dark green

Table Contd.

Table Contd.

Name of crop	Varieties	Recommended in	Green fodder yield (q/h)	Remarks
	T.55	Semi arid and arid parts	500-550	Leafy, as good as native varieties
	S.530	Throughout millet growing areas	450	Leafy, dark green, multicut, profuse tillering
	K675	Throughout millet growing areas	600	Tall, dark green
	K677	Throughout millet growing areas	600	Tall, dark green
Napier	Pusa giant	Hot humid areas	1000-1200	Fast growing, leafy
	Gujarat	Hot humid areas	800-900	Leafy, tall
	N.B.21	Hot humid areas	1200-1500	Leafy, thin stem, fast growing
	Hybrid 2	Hot humid areas	700-800	Leafy, thin stem
	Hybrid 3 and 6	Hot humid areas	700-800	Leafy
	N.B.5	Hot humid areas	800	Tall, profuse tillering
	N.B.9	Hot humid areas	800	Leafy soft stem, profuse tillering
Sorghum	J.S.20	Punjab, Haryana U.P., Rajasthan	300	Early maturing, thin stems
	Vidisha 60 1	Bihar, Haryana, M.P., U.P., Punjab	400-450	Late maturing, thick stems, tall plants
	M.P. Chari	Bihar, Haryana, M.P., U.P., Rajasthan, Gujrat	400	Early maturing, succulent, better for warm climate areas

Table Contd.

Table Concluded

Name of crop	Varieties	Recommended in	Green fodder yield (q/h)	Remarks
	Hundi	Maharashtra	330	Late maturing, good for grains and fodder
	Pusa Chari 1	UP, Haryana, Gujrat, A.P., Bihar, Maharashtra	400-425	Medium duration, Sweet succulent stems
	Pusa Chari 6	Almost throughout India	450-500	Stems thin and succulent, early maturing
	Haryana Chari	Gujrat, Haryana, Punjab	350	Early maturing
	S.C. 44	Puniab, UP, Haryana, Bihar	350	Early maturing stems thin
Sudan grass	Sweet sudan (SSG 69-3)	Throughout India	600-650	Thin succulent, multicut, profuse tillering, leafy good for summer early maturing
	J.S.4776	Southern India, Maharashtra	400	Early maturing
	J.S.6	M.P., U.P., Bihar	500	Late maturing
	S.136	Haryana, Punjab, UP	450-500	Medium duration crop
	J.69	U.P, M.P., Bihar, Rajasthan	450-500	Early maturing, multicut, good for summer cultivation better than M.P. chary in disease resistance
	Ganga 2	Plains	450	Medium duration crop
	Ganga 5	Plains of Northern India	450	Medium duration crop
	Ganga 7	Plains of Northern India	450	Medium duration
	Vijay	Throughout India	425	Medium duration, disease resistance

Water Harvesting

Depending upon catchment and land topography, this approach may have three manifestations.

Where small streams flow through the watershed, small dams are provided at desired interval to spread the runoff water in adjoining fields.

In case of a sloppy field, it is divided into 2 parts i.e. upper (the donor of the catchment) and lower (the receiver or the cropped area). Furrows of 40 to 60 cm width and 20-30 cm deep are opened along the slope at 3 to 5 meter intervals and tree crops like Zuzube are planted along them. The tree crop would thus not interfere in the process of runoff, which would be carried to the cropped area aided by furrows. Under this system, no area of the field is lost to catchment. This can be practiced in all types of soil situations.

In case of larger catchments, runoff is carried to distant places in small streams and collects, wherever it meets a depression or a natural topographic barrier, which limits its further course. The *khadins* of Jaisalmer and Barmer areas in Rajasthan are best examples of this phenomenon. Centuries of erosion from catchment have deposited fine sediments in the depression. As a result the soils in these locations are generally heavy in texture with high moisture storage capacity. Crops like wheat, mustard, gram are successfully grown during post-rainy season upon receding of water.

Desert strip water harvesting systems

Desert strip cropping uses water harvested from a collector area to help in supplying the moisture requirements of a cultivated crop on a smaller farmed area. This system was tried in Arizona (USA). An advantage of leaving the collector area in its natural state is that it can be used in its traditional manner for livestock raising.

Farm ponds

The runoff water is collected from a treated or untreated catchment and stored in a reservoir or farm pond. This stored water is utilized for supplemental irrigation during long dry spells at critical stages of plant growth.

Farm ponds are the bodies of water made either by constructing a dam or an embankment across a watercourse or by excavating a pit or dug out. Farm ponds hold great promise in areas characterized by low and erratic rainfall as a life saving device for rainfed crops. Experience has shown that a supplemental irrigation of 5 to 7 cm given to a rainfed

pearl millet at reproductive stage can make all the differences between success and failure of the crop.

Selection of Suitable Crops and Varieties

For the suitability of a crop to specific agro-climatic conditions, it is necessary that the major portion of the life cycle of the crop should fit within those portions of the year, which are favourable and the crop should use as much of the favourable season as possible to produce maximum forage. The length of the growing season, the duration during which environmental conditions are favorable for crop growth is determined mainly by the agro-climatic limitations. The depth and water holding capacities of soils may have a significant role in deciding the length of the growing season. The forage crops grown should match the duration for which the moisture is available.

The forage crop production should aim at increasing yield along with improvement in quality traits to enhance ultimately the secondary productivity (animal products). The forage crop varieties should have higher rate of dry matter accumulation and longer leaf-area duration, compatibility with associated crops in mixed/intercropping systems high palatability and greater digestibility, ability to withstand aberrant weather and adverse soil conditions, resistance to diseases and insects-pests, desirable characteristics for making good quality silage and hay (Menhi Lal, 1993)

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17. Economics

Indian breeds of sheep are poor producers of wool and mutton than their counterparts in some other parts of the world, yet they contribute substantially to our national income. The entire quantity of wool is used in manufacturing warm clothing, blankets and carpets. Most of the wool produced in our country is of the carpet variety. Apart from wool, sheep provide mutton, manure, milk and hides (Sahani *et al.,* 1981; Kaushish and Jain, 1987). They are also used as pack animals in some parts of the country over the high mountain ranges, where, other means of transportation are hard to use. The return from sheep depends on the type of sheep, i.e., the breed and other economic characters inherent in the breed such as fleece weight, birth weight, growth rate and lambing percentage.

Utility of Sheep

Sheep is an important source of livelihood to a large population in arid and semi-arid areas. In addition to wool, meat and milk, sheep provide employment to a large section of the population in these areas in the form of self-employment of persons attending their own flocks or those hired for attending flocks during migration. Economic characters of some native and crossbred sheep are given in Table 17.1. Besides grazing and management of sheep many people are engaged in the work of sheep shearing, wool and skin based industries. According to 2003 census, there were 61.78 million sheep producing 49.40 million kg of wool, 158.27 million kg of mutton, 21.41 million pieces of skin in addition to manure, casings, offals, etc. and contributes ₹ 2163.4 million per annum to the national income (Bathla *et al.,* 2005).

Economic analysis of a flock of 100 adult females based on the data recorded and survey conducted during 1985-86 in semi arid areas of Rajasthan is presented below.

Sources of income

The flock consisted of 100 adult females and 2 to 3 rams at the beginning of the year. Considering 7 per cent adult mortality, the adult

strength at the end of the year will be 93, of these, 83 ewes were available for breeding as 10 ewes may not be available due to low body weight, debility, old age, etc. Estimated number of live lambs born is 75 considering 10 per cent abortions, stillbirths, etc. The number of lambs reaching yearling age of the young stock will be 62 assuming 20 percent young mortality. Of these, 31 will be male lambs and 31 will be female lambs. The male lambs are disposed off at marketing age, which varies from 5 to 12 months. Lambs were marketed in two lots, i.e., about two fifth males during April-May (at the age of 6 months) @ ₹ ll0/- each and rest males during October-November (at the age of 12 months) @ ₹ 130/- each, giving an income of ₹ 3790.00 from sale of 31 male lambs.

The next important source of income is from sale of washed wool. Sheep are shorn twice or thrice in the area. The average annual washed wool production is 0.90 kg per adult and 0.70 kg per lamb. The total wool production from adults (90 × 0.9 = 81.00 kg), female lambs (31 × 0.70 =21.70 kg) and male lambs (31 × 0.50 = 15.5 kg) will be 118.2 kg. Market rates for washed wool ranged from ₹ 35.00 to 43.00 per kg. Considering average rate of ₹ 39/- per kg. The income from sale of wool will be ₹ 4609.80 per year.

Manure is also a source of income. A flock of 100 adult ewes will provide 156 to 170 kg manure per year. Considering average collection of 165 quintals of manure and sale at the rate of ₹ 70/per cartload of 5 quintals, the income from sale of manure is ₹ 2,310/- per year.

In some areas sheep is also milked and milk is sold. Considering average production of 250 gm during the first fifteen days and 130 gm during next 30 days, 65 adult females in milking would give 496 kg of milk. The income from sale of milk at the rate of ₹ 2.50/ kg will be ₹ 1,240/- per year.

The income from the sale of 7 hides from adult sheep and 13 hides from young ones at the rate of ₹ 12.00 and ₹ 6.00 respectively comes to be ₹ 162.00 per annum.

Total income from all the five sources listed above works out to ₹ 12111.80 per year.

Sources of expenditure

Following expenditures normally occur on the given flock size.

The cost of vaccinating 170 sheep against sheep pox and enterotoxaemia @ 10 paise each will be ₹ 34.00 per year.

The cost of health cover including drenching was ₹ 2.00 per sheep in the project area. The expenditure on health coverage will be ₹ 340/- per year.

Table 17.1 Averages for various economic characters in some natives and crossbred sheep

Breeds	Per cent Mortality											
	6 month wt. (kg)			Adult animal			Pre-weaning		Post-weaning		**Adult**	
	Native	Cross-bred	% Im-prove-ment	Native	Cross-bred	% Im-prove-ment	Native	Cross-bred	Native	Cross-bred	Native	Cross-bred
Rambouillet x												
Nilgiri	15.9	19.8	24.7	0.84	2.34	179.6	21.9	10.6	5.3	8.0	8.5	3.0
Gaddi	10.4	11.7	12.6	0.90	1.47	68.7	16.2	21.5	14.4	11.4	10.3	10.2
Chokla	12.7	15.2	19.0	*1.34	1.22	8.7	“38.3	36.7	-	-	8.5	5.4
Nali	13.5	14.6	8.5	*1.45	1.25	12.3	“51.0	33.3	-	-	9.1	7.3
Chokla	-	-	-	*1.32	1.49	14.3	28.5	10.1	48.5	10.3	10.4	7.0
Malpura	-	-	-	0.56	1.14	76.7	14.0	4.6	31.8	4.8	1.3	3.8
Merino x												
Nilgiri	15.9	18.4	16.0	0.84	2.41	187.5	21.9	5.5	5.3	2.9	8.5	3.3
Gaddi	10.4	12.4	19.3	0.90	1.53	70.6	162	21.2	14.4	16.9	10.3	9.3
Chokla	12.7	14.8	16.2	“1.36	1.20	10.5	“38.4	45.0	-	-	8.3	5.3
Nali	13.5	14.6	18.2	“1.45	1.80	11.9	“51.0	35.0	-	-	9.1	6.0
Dorset x												
Mandya	15.9	18.1	13.8	0.28	0.39	39.8	9.9	9.7	11.2	12.4	16.4	9.8
Nellore	16.6	20.4	23.0	-	0.33	-	7.8	6.0	11.3	11.5	13.6	9.9
Muzafar nagri	16.2	19.2	18.3	*0.55	0.63	15.6	*31.0	16.7	-	-	13.9	15.4

Table Contd.

Table Concluded

Breeds	Percent Mortality											
	6 month wt. (kg)			Adult animal			Pre-weaning		Post-weaning		**Adult**	
	Native	Cross-bred	% Im-prove-ment	Native	Cross-bred	% Im-prove-ment	Native	Cross-bred	Native	Cross-bred	Native	Cross-bred
Malpura	12.6	16.4	31.0	*0.54	0.58	6.3	*30.2	37.5	-	-	8.9	16.5
Sonadi	12.2	16.1	21.6	*0.43	0.51	18.5	*38.1	39.8	-	-	8.1	15.6
Suffolk x												
Mandya	15.9	18.3	15.1	0.28	0.34	20.1	9.2	15.4	11.2	15.2	16.4	7.4
Nellore	16.0	18.7	12.6	-	0.32	-	7.8	3.9	11.3	44.0	13.0	9.5
Muzafarnagri	16.2	19.8	22.2	*0.54	0.68	23.7	*31.1	14.3	-	-	13.9	8.4
Malpura	12.6	16.9	34.9	*0.54	0.54	0.9	*30.2	44.6	-	-	8.9	33.3
Sonadi	13.2	17.2	30.4	*0.43	0.48	11.4	*30.1	47.1	-	-	8.1	34.2

* 6 Monthly * Young mortality up to one year.

The shearing charges per sheep are ₹ 1.00 and the expenditure on shearing will be ₹ 320.00 per year.

Cost of purchase of *patri* (Acacia pods) for feeding sheep during lean period will be ₹ 600/- per year, cash payment of wages ₹ 600/-, two dresses *(dhoties* and shirts) ₹ 100/-, one pair of shoes ₹ 30.00 and expenditure on feeding ₹ 1,190/-.

Income

Thus the total expenditure on maintenance of a flock of 100 adult female sheep will be ₹ 3,234/- and the net income will be approximately (₹ 12,111.80–3,234.00 = 8,877.80) say ₹ 9,000/- per year. This analysis however has not taken into account expenditure on investment, repayment of loan interest, depreciation and income through increase in flock addition of 30 yearling females.

Socio Economic Survey.

Detailed economics of sheep farming worked on the basis of results obtained from socioeconomic survey conducted on sheep farming in Malpura sub-division is given here. The net annual income from owner grazed flock of 100 breedable ewes, adult rams and followers was ₹ 3,472. Supplementary feeding is rarely practised for which a provision of ₹ 810 has been made. The income from sale of milk and milk products was also estimated at ₹ 1,536 per year considering surplus saleable milk production of 400 ml/ ewe/ day for 60 days, i.e., 1536 litres milk sold @ ₹ 1.00 per kg. Annual income from sale of wool, male lambs, culled sheep, hide, manure, milk and products was estimated to be ₹ 5,819. Sale of ram lambs, wool and capital gains through increase in flock size are the major sources of income each contributing 35.2, 36.7 and 19.1 per cent, respectively, of the total income.

A survey conducted by Central Sheep and Wool Research Institute, Avikanagar (Rajasthan) on economics of sheep rearing in Chokla and Nali region in Rajasthan indicated the average income from a flock of 100 breedable ewes, adult rams and followers to be ₹ 3,861 for Chokla and ₹ 5,645 for Nali per annum. The number of lambs born per 100 ewes, lamb and adult survival and market weight determines the return from sale of ewes and ram lambs, greasy fleece weight and quality determines returns from sale of wool. The Nali ewes gave birth to more lambs per 100 ewes (67 vs. 60), survived more lambs up to one year of age (83.2 vs. 68.8) and produced more wool per year (1.5 vs 1.2 kg) resulting in almost 50 per cent higher income from a similar flock. Herbage production, ewe, ram and management, breeding, feeding and health influence the profit from sheep flock. Mortality in adult stock and

lambs has been considered @ 5 and 15 per cent, respectively. Grazing will be available free of cost. Annual lambing percentage has been considered as 75 per cent.

Bankable Project for 100 sheep unit

Assumptions:

1. The flock will have the animals of all ages as available in the field conditions.
2. The lambing is around 70 per cent with 1: 1male and female ratio.
3. The mortality in lambs is around 10 per cent. Hence the lambs will be available 63 (70-7) per year.
4. The mortality in adults is 5 per cent and adult replacement will be 30 per cent including mortality and hence 21 hoggets will be retained in the flock every year, number of hoggets available for sale, will be 63-21=42.
5. As 16 animals are replaced, so 16 animals will be culled and sold every year.
6. The capital money loaned, is ₹ 1,00,000/- with interest of not more than 16 per cent per annum and calculated annually.
7. The loan should be only a long term loan and may be recovered in 10 years.

A. Non Recurring Expenditure

1.	Cost of 100 ewes	₹ 90,000.00
2.	Cost of 4 rams	₹ 6,000.00
3.	Cost of construction of pens with thatched roofing and equipment.	₹ 4,000.00

B. Recurring Expenditure

1.	Cost of medicine @ 15/- per animal/ year	₹ 1,500.00
2.	Cost of shearing @ 06/- per adult animal.	₹ 600.00
3.	Depreciation @ 20 per cent construction of pens and equipments.	₹ 800.00
4.	Labour charges @ 1000/-per 100 ewes per month	₹ 12,000.00
	Total	₹ 14,900.00

C. Income

1.	Sale of wool ₹ 60/- per kg. 0.9 kg./adult/year and 0.4 kg./lamb	₹ 21,000.00
2.	Sale of animals 42 hoggets @ ₹ 500/- animal.	₹ 9,600.00
3.	Sale of culled animals 16 @ ₹ 600/- per animal.	₹ 4,000.00

4. Sale of manure ₹ 30/- per adult sheep and followers. ₹ 12,000.00
   Income generation through employment of family labour. ₹ 53,700.00
   Total ₹ 53,700.00
   Total Income Total expenditure ₹ 14,900.00

D. Repayment of interest and Loan Sheep Unit

Recovery of interest and loan in 10 years can be affected as follows (in ₹)

At the end of	Recovery of interest	Recovery of capital	Total recovery	Balance of loan
Ist year	16,000	-	16,000	1,00,000
2nd year	16,000	10,000	26,000	90,000
3rd year	14,400	10,000	24,000	80,000
4th year	12,800	10,000	22,800	70,000
5th year	11,200	10,000	21,200	60,000
6th year	9,000	10,000	19,600	50,000
7th year	8,000	10,000	18,000	40,000
8th year	6,400	15,000	21,400	25,000
9th year	4,000	15,000	19,000	10,000
10th year	1,000	10,000	11,600	-

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18.

Farm Records

Importance of keeping records

Sheep breeding is an integral part of farm enterprise. Using memory to plan breeding policy has its drawbacks; one cannot remember good and bad points of the flock. It becomes difficult to remember about each and every sheep of the flock. Sheep farmer can find out from farm records, where his present weakness lies and which aspect of this enterprise should be improved. The records of near relatives will give some idea of the genetic potential of the animal, since occasionally a good animal may come from a poor family and *vice versa.* The sheep farmer should be able to see from his records whether or not is being successful. Very often a farmer will find it simple and more convenient to use records on specially designed farms, but there is nothing to prevent him from making and using his own.

The recording system should be simple, accurate, and capable of collecting the required information and finally kept up to date. The data thus collected should not be kept but should be used up. In sheep growth rate, food conversion, wool quality and dressing percentages are highly heritable characters. Prolificacy, milking capacity and fleece weight are characters of low heretability. More profits can be obtained if more attention is paid to characters of high heretability. Having decided his breeding programme, a farmer must then choose his parent stock.

Method of selection on the basis of appearance gives good results. As the knowledge in this field increases, sound relationship between visible characteristics in the live animal and important economic factors may be found. Choosing sheep without any regard for their confirmation can be as disastrous as choosing them on look alone.

Good record should identify the offspring with the parents. They should also give date of birth, sex and final disposal of individual. This information together with desirable confirmation is the basis upon which selection for flock improvement should be made.

There should be a system for ear marking, tattooing and/or tagging. In case of short ear breeds, tattooing on inside of thighs or tails is practiced. A combination of tattooing and tagging is desirable. Following data observations are of great help at an organized farm.

Livestock inventory: This register gives information about the individual identification, parentage and date and reason for sale or culling.

Wool weight and quality: Wool evaluation should be limited to greasy fleece weight of each clip, staple length at a particular site, average fiber diameter, medullation percentage, visual assessment of fineness and making careful examination of undesirable characters such as black fibers or coarse fibers.

Growth records: Body weights at birth 3, 6, 9 and 12 months of age are important. Birth weight is related with vigour, survivability and growth rate. Weaning weight is used to measure total lamb production of ewe. Six month weight is correlated with market and yearling weight is highly related to adult weight and ewe productivity. Body weights of each lamb are required to be correlated to age, sex, type of birth, season and age of dam, etc.

Prolificacy: Twin-producing ewes are more profitable than single producing ewes excepting in areas, where grazing conditions are poor.

Health: Information on causes of death and incidences of diseases helps in planning prophylactic health programme.

Importance of ram: Ram is half of the flock. The improvement in a character in a flock can be made rapidly by introducing a ram with that character. The choice of a suitable ram needs a careful thought. In improving a flock the ram is more likely to have greater effect. The method of evaluating the true breeding worth of a sire is performance testing and progeny testing.

Mutton production: Efficiency of feed conversion is an economic trait with high heretability.

Breeding plan for flock improvement: All the sheep should be identified by tagging or tattooing. Record the performance on individual lamb, ewe and ram. Adjust weight of each lamb for age, sex, season, twin, age of dam, etc. Cull ewes with poor performance records, defects, wean light lambs and produce light fleece at shearing. When more than one ram is used in the flock, compare the records of the offspring and cull those rams whose off springs are below average for desired traits. Ram lambs should be selected on the basis of their own weaning weights, growth rate, quantity and quality of their wool.

Recording should be encouraged not only as an aid to management, but also to provide more accurate base for culling and selection of ewes for further breeding. Recording is essential to constructive ram breeding. The performa for recording are given in Tables 18.1 to 18.13.

Table 18.1. Daily diary

Place Date				Name of Incharge	
(i). Flock structure:					
Age				Breed and number	
	A	B	C	D	Total
Adults above 6 months					
3-6 months					
below 3 months					
Total					
ii. Shepherds:					
Attributes				Name of shepherd	
Number of sheep in flock					
Time of sending out					
Breed of sheep					
Time of return					
Pasture plot No					
Situation of plot					
Number of sheep lost					
iii On farm:					
Work				Name of shepherd	
Watering of sheep					
Cleaning					
Watchman/men					
Care of lambs					
Care of sick sheep					

contd.

Table Concluded

Total No. of shepherds	on leave	on rest	Balance

iv. Birth of lambs:

S.No.	Tag No.	Breed of lamb	Sex	Birth weight	% colour	Dam number	Weight
1.							
2.							
3.							

v. Breeding:

S.No.	Dam No.	Dam breed	Sire No.	Sire breed	Weight of dam	Remarks

vi. Weight:

S.No.	Ram lambs number /Ewe	Breed	Sex	Weight	Remarks

vii. Drenching and vaccination:

Vaccination	
Drenching	
Others	

viii. Treatment:

Sheep/Lamb No.	Disease	Treatment	Rectal temp.:

ix. Death/culling:

x. Other operations:

Docking	
Castration	

Table 18.2. Lambing Register

S.No.	Tag No.	Sex	Birth Weight	Type of .birth	Ewe		Ram		Weaning		Curling		Remarks
				Single	Twin	Tag No.	Breed	Tag No.	Breed	Age	Weight	Date	Method	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Table 18.3. Ram Record Register

S.No.	Tag No.	Breed	Sire Tag No.	Dam Tag No.	Date of birth	Nutrition		Birth		Birth	Weaning wt.	Yearly wt.	First clip wt.	Re-marks
						Natural	Artificial	Single	Twin					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Table 18.4. Sheep Register

S.No	Tag No.	Breed	Tag No.		Date of birth	Nutritional		Type of Birth			Weight at		First clip wt.	Remarks
			Sire	Dam		Natural	Artificial	Single	Twin	Birth	3 month	12 month	Weight	Quality
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Table 18.5. Lambs Register

S.No	Date of birth	Tag No.	Breed	Sex	Sire No.	Dam No.	Type of birth		Weight at		Date of castratio	Colour	Date of culling	Remarks
							Single	Twin	3 month	6 month				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Table 18.6. Breeding register

S. No.	DAM No.	Weight of dam	First service		Second service		Third service		Date of lambing	Weight of dam at lambing	Lamb		Birth of type		Remarks
			Ram No. service	Date of service	Ram No.	Date of service	Ram No. service	Date of service			Tag No.	Sex	Wt.	Single	Abortions etc.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Table 18.7. Growth register

S. No.	Tag No.	Sex	Date of birth	Breed of dam	Weight of dam at lambing	Weight of lamb						Remarks
						At birth	1 month	2 month	3 month	6 month	9 month	12 month	
1	2	3	4	5	6	7	8	9	10	11	12	13	14

Table 18.8. Wool shearing register

S. No.	Tag No.	Sire Tag No.	Dam No.	Wool weight	Measurements				Remarks
					Weight	Girth	Heart girth	Pouch girth	
1	2	3	4	5	6	7	8	9	10
1									
2									
3									
4									

contd.

Table Concluded

S. No.	Tag No.	Sire Tag No.	Dam No.	Wool weight	Measurements				Remarks
				Weight	Girth	Heart girth	Pouch girth		
1	2	3	4	5	6	7	8	9	10
5									
6									
7									
8									
9									
10									

Table 18.9. Feeding and weighing record on the feed lot emperiment

Lamb No	Sire No.	Dam No.	Date of putting in feed lot	Date of milking in feed lost	
I	II	III	IV	V	VI
Initial weight (kg)					
Initial measurements:					
L.H. H.G. PG	L.H. H.G. PG	L.H. H.G. PG	L.H. H.G. PG	L.H. H.G. PG	L.H. H.G. PG
Date Feed	Date Feed	Date Feed	Date Feed	Date Feed	Date Feed
1					
2					
3					
4					
Total	Total	Total	Total	Total	Total
Left overs	Height	Height	Pouch girth	gain during the fortnight (cm)	
Feed efficiency:					
Net feed consumed					
Final weight (kg)		Hearth girth			
Final measurement:					

Table 18. 10. Livestock strength register

S. No.	Animal indent	Sire indent	Sire breed	Dam indent	Dam breed	Date of purchase	Date of disposal	Remarks

Table 18.11. Mortality/disposal register

S. No.	Animal indent	Breed cross	Sex death/disposal	Age at death/disposal	Date of of death/disposal	Reason (s) death/disposal	Remarks

Table 18.12. Daily feed reister

S.No.	Date	Breed/ Breed/Cross	Category of animals	No. of animals	Rate of concentrate feeding	Indent of content mixture	Total concentrate remarks fed	Remarks

Table 18.13. Slaughter register

Tag No.	Breed/Cross:	Date of birth	
Sire No.	Dam No.	Date of slaughter:	
A. MEASUREMENTS (cm):			
Length	Height:	Heart girth:	Pouch girth:
B. WEIGHT (kg)	:		
1. Live weight before slaughter	:		
2. Empty live weight	:		
3. Hot carcass weight with kidneys and kidney fat	:		
4. Dressing out percentage on live weight basis	:		
5. Dressing out percentage on empty live weight	:		
6. Weight of the fore quarters	:		
7. Weight of the hind quarters	:		
8. Composition of the cuts from half carcass	:		

Name of the cut	Weight of the cut	Weight of the bones	Per cent bones
Leg loin			
Rack			
Neck and shoulder			
Breast and fore shank			
Total			

Table Concluded

9. Loin eye area (mm^2)	:
10. Offal (kg)	:
a. Blood	:
b. Head	:
c. Skin	:
d. Fore cannons with hooves	:
e. Hind cannon with hooves	:
f. Lungs with trachea and diaphragm	:
g. Gall bladder	:

	FULL	EMPTY	INGESTA
h. Stomach with Oesophagus			
i. Small Intestines	:		
j. Large Intestines	:		
k. Testicles	:		
l. Spleen	:		
m. Pancreas	:		
n. Caul fat	:		
o. Kidney fat	:		
p. Kidneys	:		
q. Heart	:		
r. Liver	:		

GLOSSARY OF TECHNICAL TERMS

Abscess	:	A localized collection of pus surrounded by inflamed tissue.
Abortion	:	Premature expulsion of a foetus before it has matured enough to survive.
Acute	:	A rapid and often severe development of a disease. Compare with chronic condition, which is continuous and long term
Additive	:	A substance included in a diet or ration, usually in small quantities to fortify them with nutrients stimulants or medicines.
Ad libitum	:	Feeding without limitation; also called free choice feeding.
Adsorption	:	The process of being taken up and held on the surface of a substance
Aerobe	:	A microorganism that requires the presence of oxygen to live and reproduce.
After birth	:	The placenta and fetal membranes expelled from the uterus after parturition
Air dry	:	Feed dried by natural air movement is termed as air dry. Most feeds are air dried and contain approximately 90± dry matter (DM).
Ambient temperature	:	Temperature surrounding the animal at any given time. The same as environmental temperature.
Amino acids	:	Organic compounds containing nitrogen that are the building blocks in the formation of proteins
Anabolism	:	The buildup of complex substances such as body tissues from simple compounds.
Anaerobe	:	A microorganism that can exist without free oxygen.
Anaemia	:	A condition in which the blood is deficient in red blood cells or haemoglobin.
Anestrous	:	The period of sexual quiescence been periods of sexual activity in cyclically breeding mammals.
Anorexia	:	A lack or loss of appetite for feed.
Anthelmintic	:	A drug or chemical agent used to destroy or control internal parasites.

Antibiotic	:	A substance that destroys or inhibits the growth and activity of microorganisms.
Antibody	:	A protein substance (modified type of blood serum globulin) development or synthesized by lymphoid tissue of the body in response to an antigenic stimulus. It provides protection against specific disease by interacting and neutralizing a disease-causing agent.
Antigen	:	An enzyme, toxin, or other "foreign" protein to which an animal's body reacts by producing antibodies specific to the invading antigen.
Antioxidant	:	A compound that prevents oxidative rancidity of polyunsaturated fats. Used in feeds and foods to prevent rancidity.
Antiseptic	:	A chemical substance that prevents growth and development of microorganisms.
Apparel wool	:	All wool suitable for manufacture into apparel fabrics.
Appetite	:	The craving for food; the desire to eat.
Artifical insemination	:	Depositing semen into the female reproductive tract by other than natural means (AI by a technician).
Ash	:	That mineral matter derived from incinerating organic matter.
Assay	:	To determine purity or potency of a substance. To determine the level of a substance in a feed.
Astringent	:	A substance that causes shrinkage or contraction, of localized blood vessels to reduce blood flow and any discharge.
Atrophy	:	Wasting away or decrease in size, usually muscular.
Average daily gain (ADG)	:	Average daily increase in body weight.
Bacteria	:	Single-cell plant microorganisms widely found in manure. Many are beneficial; others are pathogenic.
Bactericide	:	A product that destroys bacteria.
Balanced ration	:	A daily allowance of feed that provides proper amounts and proportions of nutrients.
Barren	:	Description of ewe, which fails to give birth.
Basal metabolic rate (BMR)	:	The energy required to maintain the vital functions of an animal (i.e., cellular activity, respiration, and circulation). BMR is measured in a thermo neutral environment, resting, post absorptive state, consciousness, quiescence and sexual repose.

Bellies, or belly: wool		Short and often less desirable wool from the belly of the sheep.
Biological control	:	Control of undesirable insects, other animals, or plants by the use of natural enemies of the pests.
Biosynthesis	:	The production of a chemical compound by an organism.
Black wool	:	Any fleece from sheep that is not completely white. It may contain black or brown coloured fibers that are black or grey.
Bleaching	:	Removal of colouring material in natural wool or yarn.
Bleat	:	The sound or cry of a sheep.
Blending	:	Mixing of different types of wool and thread for reducing cost or for lending some specific properties.
Bloat	:	An abnormal condition characterized by distension of the rumen on the upper left side by excessive accumulation of gas.
Blocky	:	A term indicating a conformation that is deep, wide short and low set.
Blood	:	A method of grading wool with the standards based on the amount of Merino breeding in the animal. Thus, fine for a pure Merino, half-blood, etc. It also is used to denote the amount of improved breeding in an animal.
Bolus	:	The undigested feed regurgitated during rumina tion. Also the name of a large pill.'
Brand	:	Numbers or letters stamped on animals using special paint.
Bred	:	Synonymous with pregnant. Also used to indicate mating.
Breed	:	A group of individuals that as a result of selection and breeding have similar characteristics that distinguishes them from other groups of the same species.
Breed character	:	Those characteristics that distinguish the breed from other breeds.
Breed type	:	Those characteristics that are commonly accepted as ideal for a particular breed.
Britch wool	:	Wool from the hindquarters of a sheep. It is usually the coarsest wool on the body.
Broad tail	:	The pelt from the slaughter of newborn Karakul lambs.
Broken mouth	:	Description of a sheep, which has lost some or all of its teeth.

Browse	:	To consume vegetation from trees or shrubs, food which is browsed.
Burry wool	:	Wool heavily contaminated with vegetable matter, including burrs, seeds, leaves and twigs. Such wool is discounted because of the expense of removing the foreign matter.
By-product	:	An output from a system, but not a primary product (e.g. hooves are a by-product of meat production, and straw is a by-product of cereal production).
Caesarian section	:	Removal of the foetus by surgical means at or near term. Caesarean sections are necessary if the pelvic opening is too small or when the foetus is hopelessly malpositioned.
Calcification	:	Hardening of tissues by deposits of calcium salts.
Caloric	:	Relating to heat energy.
Caraculi	:	The pelt from newborn Karakul lambs.
Carbonizing	:	Removal of vegetable matter of wool by using sulphuric acid.
Carcass	:	The dressed body of a lamb of sheep after the offal, pelt, feet and head are removed.
Carcass weight	:	Weight of the carcass on the rail, either hot or chilled.
Carcass yield	:	The percent of live weight in carcass (carcass weight +. live weight × 100). Also called dressing percentage.
Card	:	A machine for processing wool before spinning. Also a hand instrument for disentangling wool.
Carding	:	It is opening, separating and straightening of individual fibers of wool.
Carding wool	:	Fine wool with 1 1/4 - inch staple and coarse wool of 2 inch in length may be carded for the production of woolen yarn. Synonymous with clothing wools.
Carotene	:	Substance occurring naturally in green plants that is the precursor of vitamin A.
Carpet wool	:	Long staple, strong, coarse wool suitable for carpet manufacture.
Carrying capacity	:	The number of animals that can be supported on unit area of land.
Case mortality	:	The number of animals, which die, divided by the number of animals, which are sick.
Castrate	:	(a) To render sterile by removal or blocking the activity of testicles or the ovaries. (b) An animal that has been castrated.

Catabolism	:	The degradation of a complex substance into simple compounds by living cells.
Cauterize	:	To burn away or seal with a hot instrument or caustic substance to prevent infection and suppress blood flow.
Celsius (C)	:	The metric expression of temperature (formerly, centigrade). Multiplying the Celsius reading by 9/5 + 32 may do conversion to Fahrenheit.
Cereal	:	A plant of the grass family, which produces seeds, used to feed humans and livestock.
Cervix	:	The structure located between the vagina and uterus that protects the uterus during gestation.
Chronic	:	A disease condition that continues over a long period of time.
Clip	:	Total annual production of wool produced by a flock.
Clitoris	:	The reproductive organ in the female that cor responds to the penis in the male.
Clothing wool	:	Short staple wool suitable for woollen yarn production. Also called carding wool.
Coarse wool	:	Wool grading one-quarter or 46's to 48's under the Bradford system.
Coccidiosis	:	An intestinal disease caused by protozoan coccidium parasites.
Coefficient of digestibility	:	The amount of nutrient absorbed by an animal.
Colostrum	:	The first milk secreted by mammals after parturition. It is rich in antibodies and is laxative.
Combing	:	Process of removing short fibers from longer ones.
Complete ration	:	A portion of a feed or combination of feeds that satisfies the nutritional needs of an animal for one day.
Concentrate	:	Food with a high concentration of energy and little fibre (e.g. cereal)
Conception	:	(a) The union of sperm and ovum to form a zygote. (b) To become pregnant
Conception rate	:	The number of females, which conceive, divided by the number of females mated.
Conformation	:	The structure or shape of an animal.
Contagious	:	A disease transmitted by direct or indirect contact
Corpus luteum	:	The yellow body on the ovary that replaces the follicle and produces progesterone to maintain pregnancy
Cortical cells	:	Inner section of the wool fiber

Cotyledons	:	Button like structures on the placenta that attach to the maternal caruncles in the uterus of a ewe.
Creep	:	An area within a pen, corral, or pasture con structed so that it excludes ewes and allows lambs access to special feed
Crimp	:	The natural waves in wool fiber that allows it to have resilience and elasticity.
Crossbred	:	Genotype derived by crossing one breed with another (often an indigenous breed crossed with an imported breed).
Crossbreeding	:	The practice of mating parents of two or more breeds
Crude fat	:	Ether extract from moisture free feeds. It contains 2.25 times the energy of carbohydrates. It consists mostly of fats and oils, with small amounts of waxes, resins, and other organic materials
Crude protein	:	Nitrogen content of food x 6.25.
Crutching	:	The trimming of wool from around the vulva and udder of a ewe before lambing
Cryptorchid	:	A male animal in which one or both testicles have failed to descend into the scrotum. A unilateral crypt orchid may be fertile. Bilateral (neither descended) is invariably sterile
Culling	:	Removal of a ewe or ram from the flock, usually because of some defect.
Cuticle	:	Outer scale like surface of the wool fiber as seen under the microscope.
Cutting chute	:	A narrow chute with gates that allows individuals to be sorted into groups.
Dagging	:	Removal of soiled wool from a sheep.
Dam	:	Female parent or mother of an animal.
Dead wool	:	Wool pulled from dead sheep.
Deficiency disease	:	Disease resulting from lack of an essential nutrient. Usually it is a mineral or vitamin.
Dehydration	:	Loss of water from the body of an animal due to sickness or lack of drinking water.
Density	:	Number of wool fibers per unit area. Fine-wool sheep have greater density of wool than breeds with coarser wool.
Dental pad	:	That cartilaginous part of the front of the upper jaw that the lower incisors press against when the sheep grazes
Depilatory	:	Chemical solution applied to the flesh side of a sheep pelt to loosen the fibers for pulling.

Depraved appetite (pica)	:	Tendency of animals on a nutrient deficient diet to eat unnatural feed.
Dermatitis	:	Inflammation of the skin.
Diarrhea	:	Abnormal frequency of intestinal discharge. Also called scours.
Diet	:	(a) Feed ingredients including water consumed by an animal. (b) A mixture of feed ingredients fed *ad libitum* to animals.
Digestible nutrients	:	That part of each nutrient digested by an animal Obtained by subtracting fecal nutrient content from amount fed
Disinfectant	:	A strong chemical used to kill microorganisms.
Disposition	:	The temperament or personality of an animal.
Dock	:	(a) To sever the tail from a lamb. (b) That part of a sheep where the tail was cut.
Docking	:	Removal of tail.
Dorsal	:	Pertaining to or located on the back of an animal as opposed to ventral, which is the lower part or belly.
Drench	:	a) To mechanically apply oral medication. (b) The medication given orally.
Dressing	:	Ratio of dressed carcass weight to live weight, percentage expressed as percentage.
Dry	:	No lactating.
Drying off (up)	:	The process of causing cessation of lactation when lambs are weaned.
Dry matter basis	:	Expression of nutrients on a moisture free basis.
Dung locks	:	Wool from the area of the britch or twist that is contaminated by feaces
Dystocia	:	Difficulty in giving birth
Early maturing	:	Sexually mature at a young age.
Ear notching:	:	Marking an animal by cutting triangular notches in the ear according to a specified system.
Ectoparasite	:	A parasite that lives on the exterior of the host, for example, flies and mosquitoes
Edema	:	Swelling caused by accumulation of water in tissues of the body.
Elasticity	:	'The ability of a wool fiber to return to its original length after being stretched
Elastrator	:	A bloodless means of docking and castrating by use of rubber bands. The band blocks circulation and the member sloughs off.

Electro ejaculation	:	Use of a rectal probe and electrical impulses to stimulate ejaculation
Electrolytes	:	Body acids, bases, or salts necessary for proper functions of nerves, respiration, digestion and muscle contraction
Emasculatome	:	An instrument used for bloodless castration by burdizo, severing the spermatic cord without injury to the scrotum.
Emasculator	:	An instrument used for docking and castrating lambs. It has cutting blades for severing testes and tails and crushing jaws to prevent bleeding.
Endocrine	:	Ductless gland that secretes hormones necessary for the function of an animal. The hormones pass directly into the bloodstream from the glands.
Endogenous	:	Secretions originating within the body of an animal.
Enteritis	:	Inflammation of the intestines.
Enterotoxaemia	:	A toxemia or blood poisoning caused by the toxin of Clostridium perfringens; also called overeating disease
Environment	:	The aggregate of all the external conditions that affect an animal.
Epididymis	:	The convoluted tube at the posterior end of the testicle that serves as a passageway from the seminiferous tubules to the vas deferens.
Epithelium	:	Covering of the interior and exterior of the body.
Essential amino acids	:	Amino acids required by an animal that cannot be synthesized in the body.
Estrous cycle	:	The physiological events occurring in the reproductive system of an ewe between one estrous and another. Average length is approximately 17 days.
Estrus (noun) ; estrous (adjective)	:	The period when an ewe is physiologically and psychologically receptive to sexual advances of a ram. Also known as the heat or estrous period.
Ether extract (EE)	:	Substances in feed soluble in ether. Included are fats, oils, waxes, resins, etc. Energy content is 2.25 times that of nitrogen free extract or crude protein.
Ewe	:	Female sheep, which has given birth.
Excreta	:	Substances excreted by an animal, primarily in feces and urine.
Exogenous	:	Substances introduced into the body of an animal.
Exotic. breed	:	Breed from another locality (usually from a temperate country).

Expectorant	:	A medicine that promotes the discharge of mucus from the respiratory tract.
Fattening	:	Feeding animals so they will store energy in the form of fat. Also called finishing.
Fecundity	:	Ability to produce offspring.
Fecundity Feed	:	Material capable of nurturing livestock.
Feed additive	:	An ingredient or substance added to a basic feed, usually in small quantities, to fortify it with nutrients, medicines, or stimulants.
Feed efficiency	:	The relationship between feed consumed per day and increase in weight or other measure of production. Usually expressed as feed per unit of production. For example, a lamb feeder will be much interested in weight of feed required per unit of gain in live weight.
Feeder lambs	:	Lambs under one year of age that needs to grow and fatten before being suitable for slaughter.
Feedstuff	:	A product suitable for nurturing livestock.
Felt	:	A dense, lightly woven, heavily filled wool cloth.
Fertility	:	Number of ewes lambing divided by number of ewes mated.
Fertilization	:	The union of the sperm and ovum to form a zygote or independent individual.
Foetus	:	The developing organism in the uterus of the pregnant female.
Fiber content of feed	:	The content of complex carbohydrates (cellulose) and lignin in feed. These are difficult to digest and tend to lower feeding value.
Fine wool	:	The finest grade of wool corresponds to 64's or finer using the spinning count system.
Finish	:	Refers to the degree of fatness of the animal. Also used synonymously with fattening an animal.
Finishing	:	Preparing lambs for slaughter by feeding a good quality diet.
Fleece	:	The wool from one sheep.
Flock	:	A group of sheep.
Flushing	:	Giving ewes or gimmers extra food before mating, to enhance lambing rate.
Fly strike	:	A seasonal-situation in which flies irritate or attack livestock blowing sores, open wounds, incisions, or damp wool.
Forage	:	Vegetable matter consumed by livestock as pas ture, silage, or hay.

Fostering	:	Process of transferring of a lamb from its mother to another ewe. Also called grafting.
Free choice	:	Allowing uninhibited access to feed: same as *ad lib* feeding.
Fumigant	:	A substance that is vaporized to destroy pathogens, insects, or rodents.
Fungi	:	Saprophytic, parasitic lower plants such as molds, rusts, mildews and mushrooms.
FCE	:	Food conversion efficiency. Weight of product per unit weight of food input.
Generation interval	:	The time span between the same-stage in the life cycle of two successive generations.
Gestation (pregnancy)	:	Period between fertilization and parturition. Time the fetus is carried in the uterus. Average gestation for sheep is approximately 147 days.
Gimmer	:	Female sheep aged 6 months (or from weaning) to first parturition.
Gimmer lamb	:	Female lamb.
Grade	:	(a) Measure of how well an animal or product meets the standards of a class. (b) Animals that have characteristics of a breed but cannot be registered because a parent or parents are not purebred. Offspring of a purebred and one of inferior breeding. (c) The classification system used to describe greasy wool.
Grading up.	:	Increasing the proportion or exotic genotype in a flock by backcrossing ewes to exotic rams for several generations.
Grain	:	Seeds from cereal plants.
Graze	:	To consume standing vegetation.
Greasy wool	:	Wool shorn from live sheep.
Growth	:	The increase in size of the muscles, bones and internal organs.
Growth promoter	:	Substance used in small quantities to increase growth-rate, usually during finishing.
Growthy	:	An animal large and well developed for its age. Usually large-framed animals.
Gummer	:	A sheep with no incisor teeth. A sign of old age.
Hand feeding	:	Methods of feeding lambs in which they are fed grain twice daily plus hay.
Hand mating	:	Methods of mating in which the ram occupies a pen and ewes in estrous are brought to him for one service each.

Hank	:	A standard length of yarn wound on a real. Length 560 yards (512 m).
Heat (estrous)	:	The period when a ewe is physiologically and psychologically ready to accept service from a ram.
Heavy wool	:	Wool with a high shrinkage due to a high grease and dirt content.
Haematoma	:	A swelling or tumor that is filled with blood.
Haemoglobin	:	The iron-containing protein in red blood cells responsible for oxygen transport in respiration.
Haemorrhage	:	Loss of blood from blood vessels. Bleeding.
Hogg, hogget	:	Sheep aged 6 months to 2 years
Hormone	:	Substance secreted by endocrine glands that regulate the activity of organs in the body.
Hulls	:	Fibrous covering of grains and seeds. Used as roughage component of feeds.
Hypocalcemia	:	Below normal levels of calcium in' the blood, which may result in convulsions or parturient paresis as in milk fever.
Hypomagnesemia:		Below normal levels of magnesium in the blood.
Hypoglycemia : magnesemia		Below normal levels of blood glucose.
Hypothalamus	:	That part of the brain that regulates body temperature, appetite, hormone releases, and other functions.
ILCA index 2	:	Total weight of lamb weaned per unit bodyweight of ewe, per year.
Immunity	:	The ability of an animal to resist or overcome a disease by preventing development of pathogens or by counteracting effects of its products.
Immunization	:	Creating immunity by such means as vaccination.
Impaction	:	Stoppage of movement of the digestive tract by partially digested or indigestible material wedged into a segment of the system.
Inbreeding	:	Mating of related individuals.
Incidence of disease	:	The number of new cases of the disease appearing each year, expressed as a proportion of the total sheep population.
Incisors	:	The sharp cutting or biting teeth located in front of the lower jaw.
Indigenous breed	:	Breed native to the locality.
Infection	:	Invasion of the body by pathogenic microorganisms.

Inflammation	:	Reaction of tissues to injury characterized by pain, heat, redness and swelling.
Ingestion	:	The act of eating or drinking.
Ingredient	:	A constituent of a mixture.
Inguinal (ring)	:	In a male, the space or opening through which the spermatic cord passes from the interior of the body to the scrotum.
Instinct	:	A natural ability to accomplish certain tasks without benefit of prior experience. It is probably hereditary.
Intradermal	:	Within or between layers of the skin.
Intramuscular	:	Being within or going into a muscle.
Intravenous	:	By way of a vein.
In vitro	:	Observable in a test tube or other artificial environment.
In vivo	:	Occurring within a living body.
Involution	:	Return of an organ to normal size and condition from an enlargement. For example, the induction of the uterus after parturition.
IU	:	Abbreviation for international unit. A standard of measure potency of a biologic agent as specified by the International Conference for Unification Formulae. Potency is based on a bioassay that produces a particular effect. Potency is also expressed as USP units.
Joining	:	Putting ewes or gimmers to the ram for mating.
Joint ill	:	Also called navel ill. The result of invasion of pathogenic bacteria through the navel cord at birth. May cause stiff joints, peritonitis, convulsions and death.
Ked	:	An external parasite of sheep. It is an insect that lives on blood from the skin of the sheep. Often incorrectly called the sheep tick.
Kemp	:	A straight, chalky white, weak, heavy medullated fiber that will not take a dye. It is highly objectionable in wool.
Keratin	:	A complex protein substance that is the principal constituent of wool.
Ketosis	:	Also known as lambing paralysis, pregnancy disease, or twin-lamb disease. Usually observed in ewes carrying twins late in gestation. Probably caused by inadequate carbohydrate metabolism, as indicated by ketone bodies in the blood and urine.

Lactation	:	The period of milk production. The period a mother nurses her young.
Lactose	:	The sugar of milk.
Lamb	:	Young sheep, usually under 9 months, meat from young sheep.
Lambing interval	:	Period between successive parturitions (of one ewe).
Lambing paralysis	:	See ketosis.
Lambing rate	:	Number of lambs born divided by number of ewes joined.
Lamb's wool	:	Wool shorn from a lamb, 7 to 8 months old. It is softer and has spinning qualities superior to wool of the same quality from an older sheep.
Lanolin	:	Refined wool grease. Used in medicines, cosmetics and paints.
Laxative	:	A drug or feed used to relieve constipation.
Libido	:	Sexual drive or desire by the males of an animal species.
Litter	:	Number of young produced in breeds that normally have multiple births. (b) Bedding in barns.
Litter size	:	Number of lambs born divided by number of ewes lambing.
Live weight	:	Weight of an animal on foot.
Local breed	:	Breed native to the locality (indigenous breed).
Lock	:	A tuft or small finger size bit of wool that tends to cling together when shorn from the sheep.
Lot	:	The entire offering of wool for sale.
Low set	:	An animal with short legs.
Luster	:	The natural gloss or sheen of wool from long wooled sheep.
Macro elements	:	The major minerals: calcium, phosphorus, sodium, chlorine, potassium, magnesium and sulfur.
Macroscopic	:	Large enough to be visible to the naked eye.
Maintenance requirement	:	Nutrients required solely to maintain body weight.
Malnutrition	:	A ration deficient in required nutrients.
Manure	:	Usually a mixture of feaces, urine, bedding and waste feed.
Mastication	:	Chewing feed.
Mastitis	:	Inflammation of the mammary gland.
Meal	:	A mixture of ground feed ingredients.

Medicated feeds	:	Feeds containing drugs for the treatment or prevention of diseases.
Merino	:	A breed of sheep known for producing high quality wool.
Metabolic	:	Live weight $^{0.75}$ (previously defined as live weight 0.73). Usually in units of kg $^{0.75.}$
Micro ingredient	:	A feed ingredient added to a mixture in quantities of milligrams or micrograms or parts per million.
Microorganisms	:	Organisms of microscopic size such as bacteria.
Milk let-down	:	Release of milk from the alveola into the cisterns of the udder by the action of oxytocin
Minerals	:	Inorganic elements required by animals for their normal function.
Moisture free (MF)	:	Oven-dried feed subjected to 2120 ^{o}F (1000 ^{0}C) temperatures until weight becomes static. This is known as dry matter.
Molars	:	The grinding jaw teeth
Molds	:	See fungi.
Morbidity rate	:	Proportion of animals showing signs of the disease.
Mortality	:	Death or death rate.
Mortality rate	:	Proportion of the population, which dies from the disease (see also case mortality).
Mucous membranes	:	The soft membranes lining the passage and tracts of the body
Mutton	:	Meat from (adult) sheep.
Mycotoxins	:	Toxic substances produced by some moulds.
ME	:	Metabolisable energy. Digestible energy of food 'minus energy lost in methane and urine. Usually expressed in MJ.
National Research Council (NRC)	:	A division of the National Academy of Sciences that promotes the effective utilization of scientific and technical resources. For example, a subcommittee of the NRC calculates and complies nutrient requirements for animals.
Natural immunity	:	Inherited immunity to disease or parasites; not acquired immunity.
Navel ill	:	It is result of pathogenic bacteria through the navel cord at birth. It may cause umbilical abscess, peritonitis, conventions and death
Necrosis	:	Death and decay of body tissue that is still in contact with living tissue
Nitrogen	:	The ability of legumes and bacteria to convert

fixation		atmospheric nitrogen into organic nitrogen compounds and thus enrich the soil.
Nitrogen-free	:	In proximate analysis, the sum of the contents of extract (NFE) -moisture, crude protein, crude fat, crude fiber and ash are subtracted from 100 and the result is called nitrogen-free extract. It contains sugars, starches, pentoses, and non-nitrogenous organic acids.
Non protein nitrogen (NPN)	:	Simple organic compounds containing nitrogen, which can be utilized by ruminants to satisfy part of their protein requirements. Examples are urea and biuret.
Nulliparous	:	Females that have never given birth to young.
Nutrient requirements	:	Values of nutrients considered necessary for maintenance, optimum production and prevention of signs of nutritional deficiencies of animal.
Nutrients	:	Chemical substances present in feeds that are used by animals for maintenance, growth and production.
Oestrous	:	Period of sexual receptivity of ewe.
Offal	:	Organs and tissues removed at slaughter.
Offtake	:	Number of animals removed from the flock (for sale or consumption), divided by the number of animals in the flock.
Open wool	:	A wool that lacks density and may part down the back.
Ossification	:	Hardening of the bone tissues by calcification as the animal ages.
Osteomalacia	:	Softening of the bones caused by vitamin D deficiency or lack of calcium or phosphorus or an improper ratio between the two.
Ovary	:	The reproductive organ of the female.
Palpate	:	To investigate or examine by feeling or touching with the hands.
Parrot mouth	:	A defect of the mouth caused by a shortness of the lower jaw that does not permit the incisor teeth to come in contact with the dental pad.
Parts per million (ppm)	:	Equals milligrams per kilogram or milliliters per liter.
Parturition	:	The act of giving birth.
Pathogenic	:	Causing or capable of causing disease.
Pedigree	:	A written record of an animal's ancestry.
Pelt	:	The skin of a lamb as removed at slaughter.

Peritonitis	:	Inflammation of the peritoneum, the thin membrane that covers the organs of the abdomen.
Per os	:	To administer a substance by way of the mouth.
pH	:	A measure of the acidity or alkalinity of a solution with values from 0 to 14. For most acid it is 0 and most alkalies is 14, with 7 as neutral.
Photoperiod	:	Day length or period of light.
Photosynthesis	:	The formation of carbohydrates by the action of sunlight on chlorophyll in a plant.
Physiological		Healthy or normal function of a living organism.
Placenta	:	The vascular organ that surrounds and protects the fetus and provides the means by which nourishment is transferred from the mother to the young.
Pleura	:	Delicate membranes that line the thorax of an animal.
Pneumonia	:	A disease of the lungs.
Polled	:	A naturally hornless animal.
Polyestrous	:	Animals showing regularly occurring estrous throughout the years.
Posterior	:	Refers to the back portion of an individual.
Postnatal	:	Event occurring to the offspring after birth.
Preconditioned	:	Management before shipping, weaning, etc., to reduce stress. It includes vaccination, use of antibiotics and controlled feeding.
Precursor.	:	A compound converted by the body to one needed by the animal.
Prehension	:	Grasping grass or feed by the tongue, lips and teeth and conveying it to the mouth.
Prenatal	:	Event occurring to the foetus before birth.
Prevalence of disease	:	Proportion of animals, which show signs of the disease at any time.
Prepotency	:	The ability of an individual to transmit its characteristics to its offspring.
Produce	:	The offspring of a female
Productivity index	:	Measure of production of flock.
Progeny	:	The offspring of animals
Prognosis	:	An estimate of the progression and final outcome of a disease
Prolapse	:	Abnormal protrusion of an organ or part of organ.
Protein	:	A molecule consisting of chains of amino acids
Provitamin	:	A precursor of a vitamin.
Proximate analysis	:	Chemical evaluation of feedstuff. These include dry matter (DM), crude protein (CP) total digestible

nutrients (TDN), ether extract (EE), ash, crude fiber (CF) and nitrogen-free extract (NFE).

Puberty : The time an animal reaches sexual maturity.

Pulled wool : Wool pulled from the skin of sheep after slaughter.

Purebred : An animal eligible for registration in the herd book of the breed to which it belongs.

Pus : Thick, opaque, yellow-white fluid containing leucocytes, tissue debris, and microorganisms.

Quantitative : Traits that do not vary much in phenotypic extraits pression but include most of economic impor tance. Inheritance is through many pairs of genes.

Quarantine : Segregation of sick, exposed, or susceptible animals to prevent the spread of infectious disease.

Radioactive : Emitting atomic energy as in the form of alpha, beta and gamma rays.

Ram : Adult male sheep usually used for breeding.

Range wool : Wool produced by sheep on the rangelands.

Rate of passage : Time required for undigested feed to pass through the digestive tract.

Rate of return : Net annual return divided by total capital investment. on capital invested

Ration : The amount of feed supplied to an animal in one day.

Raw wool : Same as greasy wool.

Rectum : The terminal part of the colon.

Registered : Designating animals recorded in the herd book of their breed association.

Regurgitation : The movement of undigested fibrous feed from the rumen to the mouth for further chewing.

Relative humidity : The absolute humidity divided by the absolute humidity at saturation at the same temperature.

Repeatability : Correlation between repeated measurements of the same trait on animals.

Replacements : Animals selected to go into the breeding flock.

Reproductive rate : Number of lambs weaned per ewe of reproductive age per year.

Retained placenta : A placenta not expelled at birth or soon after ward.

Rigor mortis : Temporary rigidity of muscles after death.

Rolag : The neat roll of wool that comes from the hand card.

Roughage : Food with a low concentration of energy and much fiber (e.g. straw).

Rumen : The first and largest compartment in the ruminant stomach. Also called the paunch.

Rumenitis	:	Inflammation of the rumen wall.
Sacking	:	Woven fiber bags used for storing and transporting fleece usually 2.1 m long and 1.0 m in diameter.
Saliva	:	The clear liquid solution secreted by glands in the mouth that contains enzymes used in digestion of carbohydrates.
Salmonella	:	Aerobic, rod-shaped pathogenic bacteria that are the cause of severe diarrhea.
Scouring	:	Removal of impurities of wool by washing.
Scrotum	:	The bag or sack in a male that contains the testicles.
Scurs	:	Small, rounded, loose, horny growths attached to the skin at the horn pits of a sheep.
Secondary infection	:	An infection following an infection but with different organisms.
Selection	:	The decision whether or not to keep an animal in the flock..
Semen	:	The ejaculate of a ram that contains fluids from the accessory glands and spermatozoa.
Septicaemia	:	Blood poisoning caused by bacteria in the cir culatory system.
Serrations	:	The scaly surface of the outer layer of cells of a wool fiber that causes fibers to cling together in felting. Fine wool generally has more serrations than coarse wool.
Serum	:	The colourless fluid component of blood obtained after clotting.
Service	:	Mating of male and female.
Settled	:	Becoming pregnant.
Shearing	:	Clipping the fleece either by hand or power shears
Shock	:	Physical or mental disturbance as a result of major physical injury or stress.
Shoddy	:	Wool fibers recovered from used fabric. Fibers must be at least 1.3 cm in length.
Shrinkage	:	(a) Loss of weight in transit or in handling. (b) Loss of carcass weight in the cooler.
Sire	:	The male parent.
Skirting	:	Removing stained or inferior parts of a fleece on the shearing floor.
Sorting	:	Dividing wool into grades according to fineness, length, colour and vegetable content.
Spermatic cord	:	The cord that passes from the scrotum to the body and includes the vas deferens; muscle, artery, vein, nerves and lymphatics leading to and from the testicles.

Spermatogenesis : The formation and development of sperm in the testes.

Spinning : Process of converting carded or combed wool into thread.

Spinning count: A measure af the fineness of a fleece based on the length of yarn that can be spun from 454 g of scoured wool. It is expressed in hanks, which are 512 m in length. Thus 64's would produce 64 hanks of yarn per 454 g of scoured wool.

Spore : A bacterial cell with an extra thick, impervious wall that makes it resistant to sterilization.

Stag : A male castrated after secondary sexual characteristics are well developed.

Stained wool : Wool discoloured by urine, manure, or other materials that will not scour out. This detracts from the value of the fleece.

Standing heat : The highest level of estrous when the female's receptivity to the male is the greatest.

Staple : The length of the lock of shorn wool.

Sterile : Incapable of reproduction.

Sterilization : Process of destroying microorganisms by boiling or use of chemicals. Used mainly on surgical tools. Also to render an animal incapable of reproduction.

Stillborn : Born dead.

Stocking rate : Number of sheep per unit area of land.

Straw : The stems and leaves of grains, soybeans, etc, after threshing.

Stress : Any environmental factor causing bodily or emo tional tensions that interfere with an animal's internal function. .

Store lamb : Lamb, which has been growing slowly and which, is ready to enter a finishing unit.

Subcutaneous : Anything that occurs beneath the skin.

Suckle : To draw milk from a teat by sucking. To nurse.

Suint : Salts of perspiration in the raw wool fleece.

Superanumerary : Teats in excess of the two normally found on a sheep. They are usually nonfunctional.

Supplement : An ingredient added to basal feeds to improve the nutritional value.

Suppuration : Formation of pus.

Symmetry Blending together of all parts of a well-developed animal.

Synthesis	:	Production of a substance by combining simpler compounds.
Synthetics	:	Products similar to natural ones that are produced artificially.
Tagging	:	Removing the dung locks from a sheep. Usually done before breeding and shearing.
Tags	:	Dung locks occurring in wool around and below the anus of a sheep.
Tallow	:	The fat of a sheep.
Tattoo	:	A permanent marking of an animal by insertion of indelible ink under the skin, usually in the ear or flank.
Teaser ram	:	A ram used to locate ewes in estrous, the ram may be vasectomized or equipped with an apron to prevent impregnating the ewes.
Tender	:	Fever during sickness or poor nutrition.
Testosterone	:	The male sex hormone produced by the testes.
Tetanus	:	An infectious bacterial disease that results in spasms and rigidity of muscles, especially the jaw. Clostridium tetani enters the body by way of wounds.
Tetany	:	A condition in an animal characterized by tonic muscle spasms due to a physiologic mineral imbalance. Grass tetany is caused by a magnesium deficiency.
Thrifty	:	Healthy and vigorous in appearance.
Tocopherol	:	Fat soluble chemical compounds with vitamin E activity.
Tonic	:	An appetite-stimulating agent.
Total digestible nutrients (TDN)	:	A method of determining the energy value of feeds based on the digestibility of nutrients in the feed. TDN can also be converted to digestible energy (DE). One pound of TDN = 2000 calories DE.
Toxemia	:	A general, systematic toxification or poisoning caused by absorbing toxins produced by bacteria in a localized infection.
Toxic	:	Poisonous.
Toxoid	:	A toxin from pathogenic bacteria that has been created to destroy the toxicity, but with the capability of causing the formation of antibodies when injected into the body of a healthy animal.
Trace mineral	:	A mineral required in micro amounts (mg/kg or less) by animals.

Tupping : Mating.
Tupping season: The breeding season.
Twist : The number of turns per inch in a thread of yarn.
Udder : A pendulous organ consisting of two mammary glands enclosed in a common envelope and each provided with a teat also called a bag.
Underfeeding : Providing inadequate energy to maintain weight or production.
Unthriftiness : Apparent lack of vigor and vitality as shown by poor condition of hair, thin body condition and lack of growth and development.
Unwashed wool: Raw wool, unscoured wool.
Urinary bladder: The organ in the body that collects and stores urine until it is voided.
Urinary calculi : Stones formed at any place in the urinary tract. Also known as kidney stones or gravel.
Uterus : The part of the female reproductive tract where the fertilized ovum attaches and develops into the fetus.
Vaccination : An injection of a biological agent to produce live immunity to a disease.
Vaccine : A suspension of attenuated or killed microorganism that is administered to an individual for the prevention or treatment of an infectious disease.
Vagina : The part of the female reproductive tract between the cervix and vulva where semen is deposited during copulation.
Vasectomy : Sterilization of a male by removal of a section of the spermatic cord (vas deferens). The libido is not affected.
Vectors : An organism that transmits a pathogen. Usually an insect.
Vegetable matter : Any contamination of wool from plants or plant products e.g. seeds, burrs, chaff and straw.
Ventral : The lower part or surface of a body near or level with the belly or abdominal area.
Viroid : A particle of nucleic acid that is much smaller than a virus but lacks the tough protein coat of the virus. It is a disease-causing particle in animals.
Virulent : Pathogenic or capable of causing disease.
Virus : Small infectious particles that can pass through a filter; they cause disease. They consist of a tough

protein coat within which is enclosed either RNA or DNA, but not both.

Viscera : Internal organs of the body, including the heart, liver and intestines.

Vitamin : Organic substances essential in minute quantities to the nutrition of animals. They function as parts of enzyme systems to regulate metabolic processes, but do not provide energy or serve as building units in the body.

Void : To excrete faeces and urine.

Vomiting : To disgorge stomach contents through the mouth.

Warp : Yarns extending lengthwise in a loom.

Weaning : Removing young animals from their dam to terminate the suckling period

Weaning percentage : Number of lambs weaned divided by number of ewes joined, expressed as a percentage.

Wether : Castrated male sheep, older than 6 months (or weaned).

Woollens : Cloth made from woollen yarns. The fabric is not tightly woven and tends to have a soft finish. Examples are flannels and tweeds.

Woollen yarn : Yarn spun from wools that are fine but short. The wool is carded to form a weblike configuration. When the wool is spun, the yarn is not tightly twisted and the broken loose ends stick out from the thread.

Wonner : A commercial product containing an anthelmin tic to control internal parasites.

Worsted : A tightly woven fabric with a hard finish. Examples are worsted and serge

Worsted yarn : Yarn made from long fiber wool that is combed. The fibers lie parallel before being spun into tightly twisted, smooth yarn

Yearling : An animal at least 12 month of age.

Yield : (a) Percent of scoured wool from greasy wool. Yield = wt. of scoured wool/wt. of greasy wool × 100 (b) Percent of live weight that becomes carcass at slaughter. Carcass yield = wt. of carcass/wt. of live lamb × 100 Also called dressing percentage.

Yolk : Natural grease, oil and suint in wool.

BODY WEIGHTS OF LAMBS OF DIFFERENT BREEDS AT DIFFERENT AGES

Breed	Sex	Weight at different ages				
		Birth	3 Months	6 Months	9 Months	12 Months
1	2	3	4	5	6	7
Nali	Male	2.85± 0.13 (11)	12.66± 1.10 (10)	17.00± 1.29 (6)	22.13±0.97	
	Female	2.77 ± 0.17 (10)	12.94± 1.02 (10)	18.69± 0.60 (8)		
	Overall	2.81 ± 0.12 (21)	12.80± 0.75 (20)	17.97±0.65 (14)		
Chokla	Male	2.39± 0.26 (6)	12.63±1.52	19.13 ±.1.13(4)		
	Female	2.35± 0.18 (10)	13.98 ± 0.65 (9)	17.63± 0.42 (8)		
	Overall	2.37± 0.15 (16)	13.50± 0.68 (14)	18.93± 0.50 (12)		
Nali Cross	Male	316±0.05(135)	15.28±0.28 131)	2.10±0.29(121)		
	Female	3.13±0.05(108)	14.57±0.57(104)	20.51±0.26 (100)		
	Overall	3.15± 0.04 (243)	14.97± 0.97 (235)	21.66± 0.20 (221)		
Pattanwadi (P)	Male	3.37 ± 0.27 (3)	8.57 ± 0.72 (3)	12.60± 0.88 (3)		
	Female	3.16:± 0.59 (4)	8.85± 0.41 (4)	13.25± 0.22 (4)		
	Overall	3.28± 0.29 (7)	8.73± 0.38 (4)	14.97± 0.39 (7)		
Rambouillet x P	Male	3.18 ± 0.20 (13)	5.71± 0.48 (9)	12.73± 0.83 (6)		
	Female	2.94±0.09(21)	7.96±0.39(16)	12.16±0.38(14)	15.83±0.74(14)	20.26±0.74(14)
	Overall	3.03±0.09(34)	7.79±0.30(25)	12.33±0.36(20)	15.96±0.70(20)	20.70±0.73(17)
						7

Table Contd.

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Breed	Sex	Weight at different ages				
		Birth	3 Months	6 Months	9 Months	12 Months
1	2	3	4	5	6	7
Merino(ME) x P	Male	3.16±0.12(37)	8.95± 0.35(23)	13.72± 0.05(22)	17.30± 0.72(22)	23.12± 0.95(8)
	Female	3.20±0.12 (27)	8.83± 0.41 (24)	13.06± 0.61 (23)	16.75± 0.80 (22)	21.54± 0.87 (18)
	Overall	3.18± 0.07 (58)	8.89± 0.27 (47)	13.38± 0.40 (45)	17.05± 0.54 (44)	22.03± 0.67 (26)
3/4R x 1/4P	Male	2.86± 0.29(4)	12.23± 2.09(6)	17.50± 3.30(6)	21.90± 4.21(6)	29.40± 8.21(3)
	Female	2.59± 0.18 (8)	9.93± 0.53 (8)	13.19± 1.95 (5)	16.24± 1.35 (5)	19.88± 1.41 (5)
	Overall	2.72± 0.14 (17)	10.92± 0.90 (14)	15.87± 1.89 (11)	19.33± 2.40 (11)	23.45± 3.04 (8)
3/4 ME x 1/ 4 P	Male		3.46± 0.24 (4)	12.83± 1.02 (4)	17.00± 1.16 (4)	17.00± 1.16 (4)
20.40± 1.23 (3)						
	Female	2.88± 0.30 (6)	10.26± 0.16 (5)	13.54± 1.31 (5)	16.48± 1.95 (5)	19.50±1.74 (5)
	Overall	3.11± 0.04 (10)	11.40± 0.75 (9)	15.06± 0.00 (9)	18.22± 1.22 (9)	21.10± 1.36 (8)
	Male	3.40± 0.80 (27)	10.85± 0.59 (27)	14.50± 0.71 (18)	20.96± 2.03 (5)	28.00± 3.00 (2)
	Female	2.85± 0.15 (57)	10.29± 0.39 (29)	13.59± 0.46 (17)	17.73± 0.61 (12)	20.09± 0.60 (11)
	Overall	3.03± 0.35 (84)	10.56± 0.45 (56)	14.06± 0.43 (35)	18.68± 0.76 (17)	21.31± 0.63 (13)
3/4ME x 1/4Ni	Male	3.45± 0.05(2)	11.39± 0.44(44)	16.15±0.47(26)	19.43± 0.83(11)	24.00± 1.87(4)
	Female	3.20± 0.20 (2)	11.84± 0.55 (30)	15.75± 0.43 (20)	18.47± 0.64 (18)	20.94± 0.49 (18)
	Overall	3.33± 0.10 (4)	11.56± 0.35 (74)	15.98± 0.33 (46)	18.83± 0.51 (29)	21.50± 0.52 (22)
5/8Me x 3/8Ni	Male	3.40± 0.12(3)	11.22± 0.57(37)	14.42± 0.51(26)	18.48± 0.72(11)	26.00± 2.00(2)
	Female	2.65± 0.15 (2)	10.53± 0.32 (39)	14.83± 0.48 (24)	17.36± 0.65 (22)	20.53± 0.69 (22)
	Overall	0.90± 0.12 (5)	10.87± 0.32 (76)	14.44± 0.35 (50)	17.74±0.49 (33)	20.79± 0.67 (24)

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Table Contd.

Breed	Sex	Weight at different ages				
		Birth	3 Months	6 Months	9 Months	12 Months
1	2	3	4	5	6	7
3/4R x 1/4Ni	Male	-	12.31 ± 0.55 (32)	17.39 ± 0.68 (13)	21.24 ± 0.88 (5)	26.00±1.00(3)
	Female	-	11.13 ± 0.42 (23)	14.79 ± 0.62 (14)	18.07 ± 0.58 (13)	20.92±0.95(12)
	Overall	-	11.62 ± 0.36 (55)	16.04 ± 0.61 (27)	18.95 ± 0.47 (18)	21.93±0.80(15)
5/8R x 3/8Ni	Male	-	13.43 ± 0.92 (19)	19.56 ± 0.02 (9)	22.64 ±1.32 (5)	26.25±1.38(4)
	Female	-	11.36 ± 0.74 (20)	14.64 ± 0.76 (14)	18.12 ±	0.23 (13)
19.48±1.38(4)						
	Overall	-	12.37 ± 0.59 (39)	16.57 ± 0.61 (23)	19.37 ± 0.97 (18)	21.27±0.70(15)
Malpura (M)	Male	3.30 ± 0.18 (7)	17.21 ± 0.86 (7)	27.25 ± 0.25 (2)	-	-
	Female	2.98 ± 0.15 (6)	13.78 z 0.88 (6)	21.15 ± 0.55 (15)		22.63 ± 1.39 (6)
24.20±1.77(4)						
	Overall	3.15 ± 0.12 (13)	15.63 ± 0.60 (13)	21.87 ± 0.50 (17)	-	-
Sonadi	Male	3.07 ± 0.16 (16)	15.58 ± 0.75 (15)	24.88 ± 0.98 (14)	-	-
	Female	2.84 ± 0.12 (16)	13.68 ± 0.92 (14)	21.05 ± 0.67 (13)	-	-
	Overall	2.96 ± 0.10 (32)	14.66 ± 0.59 (29)	23.03 ± 0.60 (27)	-	-
Mutton Synthetic	Male	3.50 ± 0.56 (86)	18.82 ± 0.39 (53)	28.84 ± 0.48 (46)	31.55 ± 0.89 (29)	-
	Female	3.31± 0.53 (96)	16.23 ±0.30 (87)	23.72 ± 0.37 (87)	25.03 ± 0.38 (78)	-
	Overall	3.43 ± 0.38 (192)	17.21 ± 0.23 (140)	25.48 ± 0.29 (133)	27.16 ± 0.35 (107)	-
Mandya	Male	1.75 ± 020 (8)	1229 ± 0.63 (7)	19.75 ± 0.54 (4)	23.00 ± 0.00 (1)	-
	Female	1.50 z 0.30 (2)	6.50 ± 2.50 (2)	9.50 ± 1.75 (2)	11.00 ± 1.00 (2)	-
	Overall	1.70 z 0.17 (10)	11.00 ± 0.68 (9)	16.33 ± 0.63 (6)	15.00 ± 0.82 (3)	-

Table Contd.

Table Contd.

Breed	Sex	Weight at different ages					
		Birth	3 Months	6 Months	9 Months	12 Months	
1	2	3	4	5	6	7	
Mandya Synthetic	Male	2.52± 0.09 (62)	15.15± 0.40 (58)	20.65± 0.88 (20)	30.00± 1.10 (16)	-	
	Female	2.35± 0.08 (66)	13.82 ±0.34 (64)	1940± 0040 (60)	21.00± 0.42 (56)	-	
	Overall	2.43± 0.06 (128)	14.45± 0.28 (122)	19.71± 0.37 (80)	23.0 ± 0.41 (72)	-	
Nellore	Male	2.92± 0.24 (6)	13.50± 0.50 (6)	20.50± 1.16 (3)	25.00± 1.00 (2)	-	
	Female	2.19± 0.17 (5)	1340± 0.50 (5)	1340± 0.48 (5)	20.13± 0.28 (4)	-	
	Overall	2.59± 0.15 (11)	14.45± 0.59 (11)	16.06± 0.51 (8)	21.75:± 0.35 (6)	-	
Nellore Synthetic	Male	3.18:± 0.12 (SO)	14.75± 0.60 (44)	24.40± 3.53 (5)	29.25 ± 3.58 (4)	-	
	Female	3.22± 0.08 (51)	14.35± 0.45 (50)	20.63± 0.49 (49)	22.49 ± 0.44 (47)	-	
Deccani (De)	Male	3.04± 0.08 (43)	11.77± 0.56 (35)	18.54± 0.88 (32)	-	-	
	Female	3.01± 0.08 (40)	12.37± 0.33 (26)	15.92± 1.25 (26)	-	-	
	Overall	3.02± 0.06 (83)	12.03± 0.35 (61)	17.37± 0.74 (58)	-	-	
Me x De	Male	3.35± 0.10 (15)	12.89± 0.60 (13)	20.54± 1.12 (13)	-	-	
	Female	3.12± 0.13 (16)	10.97± 0.64 (14)	14.75± 0.84 (14)	-	-	
	Overall	3.23± 0.08 (31)	11.90± 0.44 (27)	17.54± 0.69 (27)	-	-	

Table Contd.

Table Concluded

Breed	Sex	Weight at different ages				
		Birth	3 Months	6 Months	9 Months	12 Months
1	2	3	4	5	6	7
Dorset (Do) x De	Male	3.68 ± 0.05 (109)	12.83± 0041 (84)	20.06:± 0.47 (76)	-	-
	Female	3.57± 0.45 (136)	13.14± 0.27 (02)	17.28± 0.32 (100)	-	-
	Overall	3.62± 0.35 (245)	13.00± 0.24 (186)	18.48± 0.37 (176)	-	-
Muzzafar Nagri (Mu) 40.85± 0.82 (11)	Male		3.51 ± 0.09 (51)	16.76± 0.50 (50)	22.90± 0.74 (32)	28.56± 0.79 (33)
	Female	3.42± 0.10 (50)	15.82± 0.50 (46)	19.66± 0.45 (42)	24.56± 0.45 (53)	29.60± 0.55 (48)
	Overall	3'4± 0.06 (101)	16.31± 0.35 (96)	21.06± 0.45 (72)	26.16± 0.41 (86)	31.70± 0.47 (59)
1/4Do x 1/4 Suffolk x 1/2Mu 41.16± 1.57 (5)	Male		3.63± 0.14 (19)	18.00± 0.57 (15)	32.20± 0.09 (18)	30.91± 1.12 B (7)
	Female	3.31 ±0.10 (30)	1624± 0.62 (28)	21.43± 1.21 (18)	25.00± 0.75 (18)	30.15± 1.27 (17)
	Overall	3.43± 0.08 (49)	16.86± 0.46 (43)	26.81± 0.81 (36)	26.65± 0.63 (25)	32.65± 1.05 (22)

LIVE WEIGHT GAIN IN DIFFERENT BREEDS

Countries	Breed	L W G *(g/d)*	Age at weaning	References
Brazil	Blackhead Persian	117	112	Figueiredo *et al.,* 1982
	Coniedale X Illde-France	240	30	Surreaux *et al.,* 1980
	Morada Nova	119	112	Figueiredo *et al.,* 1982
	Santa Ines	152	112	Figueiredo *et al.,* 1982
Cyprus	Awassi	240	35	Lawlor *et al.,* 1974
	Cmos	230	35	*Lawlor et al.,* 1974
	Cmos	183	42	Mavrogenis, 1982
	Cyprus fat Tailed	230	30	Lawlor *et al.,* 1974
India	Deccani	116	28	*Gupta et al.,* 1974
	Madras Red	100	119	Ganesakale, 1975
	Malpura	89	28	Bohra *et al.,* 1979
	Mandya	81	119	Ganesakale, 1974
	Merino x Deccani	105	28	*Gupta et al.,* 1974
	Muzaffarnagari	122	80	Ali *et al.,* 1980
	Nali	90	84	Gaur *et al.,* 1977
	Rambouillet	162	21	Sahiti and Tiwari, 1975 b
	Rambouillet × Chokla	156	21	Sahni and Tiwari, 1975 b
	Rambouillet × Deccani	118	28	Gupta *et al.,* 1974
	Rambouillet × Jaisalmeri	160	21	Sahni and Tiwari, 1975 b
	Rambouillet × Malpura	153	21	Sahni and Tiwari, 1975 b
Indonesia	Javaneses Thintailed	51	91	Hetzel *et al.,* 1982
	Javaneses Thin Tailed Suffolk	173	91	Hetzel *et al.,* 1982
Iran	Karakul	21	-	Farid *et al.,* 1976
Iraq	Awassi	165	120	Eliya and Juma, 1970
Kenya	Masai	173	153	Wilson *et al.,* 1981

Table Contd.

Table Contd.

Countries	Breed	LWG (g/d)	Age at weaning	References
Mexico	Romney Marsh	193	30	Ugalde Orta, 1978
Nigeria	Uda	118	91	Buvanendran *et al.,* 1981
	West African Dwarf	48	30	Adeleye and Oguntona, 1975
	Yankasa	109	91	Buvanendran *et al.,* 1981
Srilanka	Jaffna	45	91	Ravindran *et al.,* 1983
Sudan	Baggara	140	91	Wilson, 1976
	Desert Sudanese	157	42	Pollott and Ahmed, 1976 b
Trinidad	Barbados Blackbelly	102	21	Rastogi *et al.,* 1979
	Blackhead Persian	188	84	Butterworth *et al.,* 1968
	Blackhead Persian	125	21	Rastogi *et al.,* 1979
	West African	116	21	Rastogi *et al.,* 1979
Venezuela	West African	122	-	Combellas, 1978
	West African x Dorset Horn	171	-	Combellas, 1978

NB : L W G = Live Weight Gain

BOTANICAL AND COMMON NAMES OF SOME FODDER TREES

S.No.	Botanical name	Assamese	Bengali	Gujarati	Hindi /Rajasthani	Kannada
1	2	3	4	5	6	7
1.	*Acacia catechu*	Khoira	-		Khair	Kangli
2.	Acacia nilotica	-	-		Babul	Jali
3.	*Adina cardifolia*	Roghu, torakepapa, bonglong phurkhona;	bangka, petipuria, kelikadani.	Haladwan, Haldaxvo.	Haldu, hardu, karam, kaim, kalmi	Hedde, pettega. yetteda, anavu, yettagal, arasintega, kdambe.
4.	*Aegle marmedos*	-	Bela	-	Bel	Bila patri
5.	*Ailanthus excelsa*		-		Mahrukh, ardu, arua.	arua, Peetheral.
6.	*Albizia chinensis*	Chakua	Chakua	-	Siran	Kalbage.
7.	*Albizia lebbek*	Nirith.	Sirisha	Pilo sarshio	Siris, Sirs, kan, bage, sirsul	-
8.	*Anogeissus latifolia*	-	-	-	Bakli, dhaura dhau,	-
				-	dhawa	-
				-	Dindal, dinduga	-
9.	*Anogeissus pendula*	-	-	-	Dhokra, kardhai	-
10.	*Artocarpus heterophyllus*	-	-	-	Kathar	Halsu.
11.	*Azadirachta indica*	-	Nim	Limba	Nim	Bavina
12.	*Bauhinia variegata*	Bogakat, Kotora.	Rakta-kanchan	-	Kachnar	Kanchava-lado, kanchi vala.
13.	*Buten monosperma*	-	-	-	Dhak, palas	Muttuga.
14.	*Careya arborea*	Dambel, Kumbhi.	Kumbi.	Kumbi.	Kumbi	Doddala, kaval.
15.	*Celtis australis*	-	-	-	Khirak	

Table Contd.

Table Contd.

S. No.	Malayalam 8	Marathi 9	Nepalese 10	Oriya 11	Punjabi 12	Tamil 13	Telgu 14
1.	-	Kadori	-	-	Khair	Karungali	Sundra
2.	Karuvelum	-	-	-	Kikar	Karuvelum	Nilla tumma
3.	Maja-kadambu yebudijamaram	Heddi, heddu, honangi, kalamb	-	kurum	haldu	bandaru	pasupu-kadambi, bandaru, dadduga, kanapu, rudraganapa
4.	-	-	-	-	-	Vilva	Maredu
5.	Peenari	Makarukh	-	Maha nim.		Pimaram, pinari, periamaram.	Peddamanu
6.	-	Laeli	-	-	Ohi	Pilivagai	Konda chigara
7.	Vaga,vaka	chichola	-	Tinia, shirson	Sirin	vagei, vagai	Dirsinam
8.	Vella-naga.	-	-	Dhau.	-	Villay-naga.	Chiriman
9.	-	-		-		-	-
10.	Pilau.	Phannas.	-	-	Kathal.	Pilla	Panasa
11.	Veppu	Limba	-	-	Nimb.	Veppam	Vepa
12.	Kotidaram	-	-	-	Kachnar	Segapumanchorii	Devakanchaanmu Bodantam
13.	-	Paras, palas.	-	-	-	Parasu	Moduga
14.	Alam, pera, peal.	Kuba, kumbia.	-	-	-	Ayama kal-kambi	Gadava, arava
15.	-	-	-	-	Kharik.	-	-

Table Contd.

Table Contd.

S.No.	Botanical name	Assamese	Bengali	Gujarati	Hindi /Rajasthani	Kannada
1	2	3	4	5	6	7
16.	*Cardia dichotoma*	-	Buhal, bohari.	-	Lasura, bhokar, borla.	Challe.
17.	*Dalbergia sissoo*	Sissu	Sisu.	Tanach,	Shisham, sissu, sisam.	Agara, sisharnage isam
18.	*Diospyros melanoxylon*	-	Kendu.	Tembru.	Tendu	Balai
19.	*Ehretia laevis*	-	-	-	Chamror, koda, tarnbolia.	Adak
20.	*Ficus bengalensis*	-	Bar, bor.	Vad, Vadlo.	Bar, Bargad.	Alada, mara, vata
21.	*Ficus glomerJilta*	-	-	-	Gular, umar	-
22.	*Ficus lacar*	Prob, Kangji	Pakar, pakur,	- Pakar.	Bassari.	
23.	*Ficus religiosa*	-	Aswattha.	Pipro pipul.	Pipal	Araliashwattha.
24.	*Ficus roxburghii*	-	-	-	Timla, tirmal	
25.	*Grewia optiva*	-	-	-	Bihul, bhimal, dharnan.	
26.	*Hardwickia binata*	-	-	-	Anjan.	Karma, karachi
27.	*Holoptelea integrifolia*	-	-	-	Papri, Papar, kanju, karanji, chilla, banchilla, kunj, bisenda.	Tapasi.
28.	*Kydia calycina*	Pichhola, bankopah, kukuha	Pala, bankopas	Varang, petari.	Pula puli, pathera, pola, safed, dhaman.	Bellaka, bendi, billubhendy
29.	*Lilgerstroemia parviflara*	-	Sidha.	-	Dhaura, lendia.	Channangi.
30.	*Lilnnea caromandelica*	-	Jial.	-	Jhingan, jigna, kaimal, ginnjan	Gugul

Table Contd.

Table Contd.

S. No.	Malayalam	Marathi	Nepalese	Oriya	Punjabi	Tamil	Telgu
	8	9	10	11	12	13	14
16.	-	Bhokar, shelu	-	-	-	Vidi.	Iriki.
17.	-	-	-	Sisu, sissua, padimi	Tali, tahli, shin, shisham	Sissoo, yette, nukku kattai, gette.	Sissu, karra, sissu Karra
18.	Kari.	Temru	-	Kendu	-	Karai, karundumbi	Tumki
19.	Chavandi.	Datrang	-	-	-	Addula	Pogadi
20.	Ala, vatam, Wad,	Vada	-	-	Ala, alam	Marri, peddamari	-
21.	-	Umbarumra	-	-	-	-	Atti
22.	Cherla.	Kel	-	-	Palakh, pilkhan.	Malai icchi	Jatijuvi
23.	Arasu, ashvatham.	Ashvatha	-	-	-	Arasi, ashwaiham	Ashvatthamu, ravi, ragi
24.	-		-	-	-	-	-
25.	-		-	-	-	-	-
26.	-	Anjan.	-	-	-	Acha	Vepi, naryepi, yana
27	-	Papara, wavuli.	-	-	Rajain.	Aya, avali	Tapasi
28.	Velukhu, venda.	Warung, potari, ranbhendi.	-	Bankopasia, bharimo kopasia	Pola, pula.	Vendai, bendi, pula, vattakannu	Potri, hondapatari, pandiki, peddapotri
29.	-	Bonda, bhondara	-	-	-	Ventek	Chennangi
30.	-	Moi, shembat	-	-	-	Uthi, odi	Gumpan

Table Contd.

Table Contd.

S.No.	Botanical name	Assamese	Bengali	Gujarati	Hindi /Rajasthani	Kannada
1	2	3	4	5	6	7
31.	Leucaena leucocephala	-	-	-	Koo, babul	-
32.	M*adhuca longifolia*	-	Maul, mohwa	Mohuda, mahudo, mavdo	Mahua, mohwa, maul	Ippahal tumbri, hippe, honge
33.	*Mallotus philippinensis*	-	-	-	Rohni, roini, rainy	Kapila
34.	Melia azedarach	-	-	-	Bakain	Kadbevu, bevu
35.	*Mitragyna parvifolia*	-	Guli kadam	-	Phaldu, karm	Kadawar, yetega
36.	*Moringa oleifera*	Saijna, sohjna.	Sujina	-	Sanjana, sohanjna	Nuggi
37.	*Morus alba*	-	Tut	Shetur setur	Shahtut, tut, tutri chinni	Kambilimara,
38.	*Ougeinio: oojeinensis*	-	Bandhar	Tanach	Sandan, chanjan, tinsa, tinas	kamblihaunu
39.	*Pongamia pin nata*	-	Karanja	-	Karanj, papar, kanji	Batti, hongay
40.	*Prosopis cineraria*	-	Shami	Semru, sami, kehjri, khejra, khijado, sumr.		Jambi

Table Contd.

Table Contd.

S. No.	Malayalam 8	Marathi 9	Nepalese 10	Oriya 11	Punjabi 12	Tamil 13	Telgu 14
31.	Illupa	Moho, mohwa, mohwra		Madgi, mahula, moha	Mohwa	Illupai, elupa, kat-illipi	Ippa, ippi, yeppa
32.							
33.	-	-	-	-	Kamila	Kapila	-
34.	Kattuveppa	Pejri, padrai	-	-	Bakain	Malai vembu	Thurakavepa, yerri vepa
35.	-	Kalamb	-	-	-	Chinna kadambu	Rattaganapa
36.	Moringa	Shevgi	-	Sajina	Suhanjana	Murunga	Saihan
37.	-	Tut, ambat	-	Tuto, tuticoli	Tut, shahtut	Mussuketi, kamblichedi	Reshma chattu
38.	-	Tiwas	-	Bandhano	-	Kallu, mokke	-
39.	Pongu	Karanj	-	Korojo, korjoi	Sukhchain	Ponga, pungam	Kagu, kanuga
40.	Parampu	Shema, shemri, semder	-	Shami	Jand.	Perumbay, jambu	Jammi chettu

Table Contd.

Table Contd.

S.No.	Botanical name	Assamese	Bengali	Gujarati	Hindi /Rajasthani	Kannada
1	2	3	4	5	6	7
41.	Quercus dilatala	-	-	-	Moru, tilonj	-
42.	*Quercus glauca*	-	-	-	Bani, banni, phaliant phanat,	-
43.	*Quercus leucotricfwphora*	-	-	-	Ban, banjo	-
44.	*Roginia pseudoacacia*	-	-	-	-	-
45.	*Schleichera oleosa*	-	-	-	Kusam.	Sagada.
46.	*Shorea robusta*	Hal, sal, borsal.	Shal	-	Sal, sakhwa, sakhu	-
47.	*Syzygium cumini*	-	-	-	Jamun	Nerlu.
48.	*Tamarindus indica*	Teteli.	Tintiri	-	Imli	Hunase, hunasemara.
49.	*Terminaliaalata*	Amari.	-	Sadada	Sain, asna	Matti, karimaddi.
50.	*Terminalia belerica*	-	-	-	Bahera	Tare, gating, bherda
51.	*Ziziphus mauraliana*	-	Ber baroi	Bor, bordi	Ber	Yalachi, elanji.
52.	*Acacia lcucophloea*	-	-	-	Safed kikar, reru, rinj, raunj, rhea	-
53.	*Albizia odoralissima*	-	-	-	Kali siris, bansa	Bilkumlu, bilwara.
54.	*Albizia procera*	Medeloa	Koroi	-	Safed siris, gurar, karak.	Chikul, bellati.
55.	Anthocephalus chinensis	Roghu.	-	-	Kadam	Kadwal.

Table Contd.

Table Contd.

S. No.	Malayalam 8	Marathi 9	Nepalese 10	Oriya 11	Punjabi 12	Tamil 13	Telgu 14
41.	-	-	-	-	-	-	-
42.	-	-	-	-	-	-	-
43.	-	-	-	-	-	-	-
44.	-	-	-	-	-	-	-
45.	-	-	-	-	-	Pava, puvan.	-
46.	-	-	-	Salwa, sakwa, soringhi.	-	Gugal, tharnba, sarjakamu	-
47.	-	Jarnbul.	-	-	-	Naval	Neredu.
48.	Puli	Chinch.	-	-	Imli.	Puliyarnararn.	-
49.	Thenpavu.	Ain, madat.	-	-	-	Karimarudu.	Maddi, nallarnaddi
50.	-	-	-	-	-	Tani.	Tandi.
51.	Elentha.	Bor, bera.	-	Barkoli, bodokoli.	-	Elandai, yellande.	Reegu, gangareegu Karakandhavu
52.	-	Hewar.	-	-	-	Velvaylarn.	Tella tuma.
53.	-	-	-	-	Karmaru.	Karu vagai	-
54.	Vellavuka.	Kinhai.	-	-	-	Velvagal	Chigara, telia chinta.
55.	-	-	-	-	-	Vellei kadarnbu	Kadarnbu.

Table Contd.

Table Contd.

S.No.	Botanical name	Assamese	Bengali	Gujarati	Hindi /Rajasthani	Kannada
1	2	3	4	5	6	7
56.	*Artocarpus cluzpiasha*	Cham, sam.	Chaplash, chaplis			
57.	*Bauhinia malabarica*	Kattra.	Karmai.		Amli, amlosa	Shadlu.
58.	*Bauhinia purpure*	Kurial.	Devakanchan, raktakanchan.	Chambali.	Khairwal, karar, koliar, kaniar.	Sarul, baswanapada, kanchival
59.	*Bauhinia racemosa*		Banrai.	Ashitri, asintro.	Arnli, jhijeri, jhanjhora, rnakuna, jinja.	Banne.
60.	*Bauhinia semla*	-	-	-	Kandla, sernla, kural.	-
61.	*Bombax ceiba*	Hirnala, hirnale.	Sirnul, shemhel.		Sirnalo, shimul. Buruga, burla.	Semul, semal.
62.	*Boswellia serrata*	-	-	-	Salai, saler.	Maddi.
63.	*Bridelia retusa*	-	-	-	Kaj, khaja, karka, kassi.	Muljane.
64.	*Buchanania latifolia*	-	-	-	Chiroli, piyal, paira, achar, char.	Nurkal, murkala.
65.	*Dillenia pen tagyna*	Aksi.	Tatri, karkotta.	Sonchernpo.	Aggi, kallai.	Kaltega, kanagola kangal.
66.	*Emblica officinalis*	Ambuki.	Amla.	-	Aonla, amla.	nelli.
67.	*Ficus cunia*	-	-	-	Khini, khunia, khain, jharphali.	-
68.	*Ficus izispida*	-	-	-	Gabla, kath gular, kagsha.	-

Table Contd.

Table Contd.

S. No.	Malayalam 8	Marathi 9	Nepalese 10	Oriya 11	Punjabi 12	Tamil 13	Telgu 14
56.	-		-	-	-	-	-
57.	Aram puli.	-	-	Koteli	-	Atthi	-
58.	Survannam andaram.	Atmatti.	-	Sono	Kolar	Mandarai	Kanchan.
59.	-	Apta.	-	-	Taur, kosundra	Archi, vattathi	Ari.
60.	-		-	-	-	-	Nirpa.
61.	Seemapula, pula.	Savar, syar.	-	Bora, bush, salmali	Simbal	Ilavam, elevamarum	Buruga, sahnali.
62.	-	-	-	-	-	Kundrikam	Anduga.
63.	-	Asana, kutki.	-	-	-	Mullu maruthu	Koramadi.
64.	Munga, perlu.	Char, chirauli, chiranji.	-	-	Chiroli	Morala, sarai	Morli, sara.
65.	Punna, kodapunna.	Karmal, kanagalu, karl.	-	Rai	-	Kanagala, kangal, nai, teku.	Pedda, kalanga, ravudana, karuva.
66.	nelli.	-	-	-	-	-	-
67.	-	-	-	-	Aola, amli-.	Nelli.	Usirikai.
68.	Eruma nakku.	Kalaumber.	-	-	-	Chona atthi	Bamori.

Table Contd.

Table Contd.

S.No.	Botanical name	Assamese	Bengali	Gujarati	Hindi /Rajasthani	Kannada
1	2	3	4	5	6	7
69.	*Ficus palmlta*	-	-	-	Pheru, phedu, khemri, anjiri.	
70.	*Ficus retusa*	-	-	-	Barri.	Pilala.
71.	*Ficus rumphii*	-	Galasvattha	-	Pilkhan, khabar.	
72.	*Flacourtia indica*		Benchi, baichi, katai.	Galgugal, katamla.	Katai, kakein, kukai, bilangra, kaikun, kanker.	Hummunki.
73.	*Gardeni1z latifolia*	-	-	-	Papra, pindalu.	
74.	*GardeniD. turgida*	-	-	-	Thanela, karamba, ghurgia.	Bengeri.
75.	*Garuga* pin *nata*	-	-	Shewan.	Kharpat, kaikar.	Godda.
76.	*Gmdina arboreo.*	Gomari.	Gumbar, gomari.	-	Gumhar, sewan.	Shivani.
77.	*GrewiD. elastica*	Bijal-goch, man-bijal.	Dhaman		Dhaman, phalwa.	
78.	*GrewiD. tiliaefolia*	-	-	Dhamana.	Dhaman.	Dadsal, butale.
79.	*Hymenodictyon excelsum*	-	-	Dondra.	Bauranga, bhaulan, kukurkat, barthua	
80.	*Manfera indica*	Ghariam.	-	Ambo.	Aam.	Mavu, majinamera.

Table Contd.

Table Contd.

S. No.	Malayalam	Marathi	Nepalese	Oriya	Punjabi	Tamil	Telgu
	8	9	10	11	12	13	14
69.	-	-	-	-	-	-	
70.	Kal atthi.	Nandruk.	-	-	-	Iehi.	Yera juvi
71.	-	Pair, sahta.	-	-	-	-	-
72.	-	Paker, kaker,	-	Balibh-	Kukai, kakoa.	Sottaikala,	Gandregu, cholhakilai
	-	bhekal.		ainchol.			giamehetu
73.	-	Ghogar.	-	-	-	-	Pedda bikki gegar
74.	-	Phetra, pendra.	-	-	-	-	Yerra bikki
75.	-	Kudak.	-	-	-	-	Garuga, gargu
76.	Kumbil.	Shivan.	-	Gambari.	-	Gumadi.	Gumartek,
	-				-	gummadi.	
77.	-	-	-	Mirgichara.	Dhaman,	-	-
	-				phalsa, pheru.	-	-
78.	-	Dhamani.	-	-	-	-	-
79.	-	Bhorsal.	-	-	-	-	Pottaka
80.	Mavu.	Amba.	-	-	Amb.	Maa, mamaram.	Mamidi

Table Contd.

Table Contd.

S.No.	Botanical name	Assamese	Bengali	Gujarati	Hindi /Rajasthani	Kannada
1	2	3	4	5	6	7
81.	*Manilkara hexandra*	-	-	-	Khirni	-
82.	*Moros saraia*	-	-	-	Kimu, chimu, kahun	-
83.	*Olea ferruginea*	-	-	-	Kahu	-
84.	*Populus Ciliata*	-	-	-	Pahari pipal, chalaun, chalni, safeda, ban pipal, bagnu	-
85.	*Pterocarpus marsupium*	-	-	Bio	Bija sal, Honne	-
86.	*Quercus semecarpifolia*	-	-	-	Kharsu, maru, kreo, khor	-
87.	*Salix tetrasperma*	Bhe	-	-	Bed, bains, bilsa, birsa	Niranji
88.	*Saymida febrifuga*	-	-	-	Rohan, rohini	Suami
89.	*Sponduis pinnaia*	-	-	-	Amra, ambara	Amate
90.	*Stereospermum suaveolens*		-	Parul, parub	-	Padal, pandri Pudika, geri, hooday, billa
91.	*Terminalia arjuna*	-	-	Dhaula sadar		Arjun, koha Holematti
92.	Terminalia chebula	-	-	-	Harad, harra	Anale
93.	*Terminalia paniculaia*	-	-	-		Bill-mathi, hulve, honal
94.	*Toona ciliata*	Poma.	-	-	Tun, tuhi, maha nim	Tundh
95.	*Trema orientalis*	Jhupon, jopang. Jiban chickan		Kargol.	Dudhi, keor, darbela	Gurkulu
96.	*Wrightia tomentosa*					-
97.	*Zizyphus xylopyrus*	-	-	-	Kat-ber, chitena, ghat-bor, g.oti	-

Table Contd.

Table Concluded

S. No.	Malayalam 8	Marathi 9	Nepalese 10	Oriya 11	Punjabi 12	Tamil 13	Telgu 14
81.	-	Ranjana, raini.	-	-	-	Palla.	Pala.
82.	-		-	-	-	-	-
83.	-		-	-	Kau.	-	-
84.	-		-	-	-	-	-
85.	-	*Bibla, asan.*		-	-	Vengai.	Yegi, peddagi.
86.	-		-	-	-	-	-
87.	Vanti.	*Bacha, bitasa*	-	-	-	-	-
88.	-	*Pahlra*	-	Sohan.	-	Shem	Sumi
89.	-	*Ambadtz, ambe*	-	Ambota.	-	Ambalam	-
90.	Kariyam, vedanko-rana.	*Parul, kala-gari, patahl*	-	Boro-pat- uli, padal.		padiri	Kala geru
91.	-	*Savirruulat*	-	-	-	Kula marutha	Thella maddi
92.	-	*Hirdo*	-	-	-	Kadakai	Karaka
93.	-	*Kinjal, kinda1*	-	-	-	Admarud, pulavati, vanmarduu, Pumarudu.	Nimiri, pula, maddinalla- pulaga
94.	Rachagiri vembu	*Tadu*	-	-	-	Thevatharam	-
95.	Ami, ratthi	*Kagal, gal ranambado*	-	Jivani	-	Oman, oma	Gada-nelli
96.	-	*Kala indarijau*	-	-	-	Pala.	Tella palla
97.	-	*Gati*	-	-	-	Kottai.	-

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About the Book

The subject of sheep production and management has been introduced in many agricultural universities at graduate and postgraduate levels. Many books have been written by foreign authors and we have been following them. As the climate of this region is different from that of those countries, these publications are far away from realties under our conditions. The aim of this book is to present consolidated information on different aspects of sheep production accrued through research and development programmes undertaken during the last five decades. Very few books have been written on sheep management under our conditions. As these are not according to the syllabi being followed in agricultural universities. The author has brought out the present book keeping in view the requirements of undergraduate and postgraduate students of sheep production, the teachers, scientists, farm managers and planning officers, development agencies and administrators. Some of the important aspects covered are — Breeds of Sheep, Housing, Establishment and Culling, Management, Reproduction, Embryo Technology, Biotechnology for Small Ruminants Production, Health Management, Nutrition and Economics etc.

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